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HELIOS RADIOMETER EXPERIMENT

Prepared for:

National Aeronautics and Space Administration

Goddard Space Flight Center

Radio Astronomy Branch

Laboratory for Extraterrestrial Physics

Greenbelt, Maryland

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16. Abstract

The HELIOS Dual Swept Frequency Radiometer, used in conjunction with a Government furnished dipole antenna, was designed to measure Electromagnetic Radiation in space.

An engineering prototype was fabricated and tested on the HELIOS spacecraft. Two prototypes and two flight units were fabricated and three of the four units were integrated into the HELIOS spacecraft.

Two sets of Ground Support Equipment were provided for checkout of the Radiometer.

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PREFACE

This report describes the development and fabrication of a Flight Experiment Electronics Package. The equipment, Helios Dual Swept Frequency Radiometer, was designed and built by WTA to satisfy the needs of the Government as described in the Technical Specification contained in Contract NAS5-11396 issued by the Goddard Space Flight Center to WTA on 17 March 1971.

Included is a summary of activities, a description of the Radiometer, and other related information.

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SECTION 1

INTRODUCTION

1.1 SUMMARY

A contract was awarded to WTA to design and produce a dual swept frequency radiometer system for use on the Helios Spacecraft. Under the provisions of the contract the following items were to be produced:

a) Engineering test unit (ETU) Radiometer and preamplifiers

b) Prototype 1 Radiometer and preamplifiers

c) Prototype 2 Radiometer and preamplifiers

d) Flight 1 Radiometer and preamplifiers

e) Flight 2 Radiometer and preamplifiers

f) Ground Support Unit (2 units)

g) Test plans

h) Engineering Drawings

i) Calibration Data

Contract No. NAS5-11396 was signed on 14 July 1971, and work was begun immediately to develop a radiometer to meet the requirements of Specification No. S-693-P-2, "GSFC Procurement Specification for Helios Dual Swept Frequency Radiometer System" dated 29 July 1970 and the related requirements specified in GSFC Specification for Reliability and Quality Assurance Provision for Helios Project Instrument No. S-702-P-1A dated 7 August 1970.

The technical specification was further modified by amendments 2 and 3 to the basic contract.

1.2.1 Engineering Test Unit

The design progressed through the theoretical, breadboard and basic layout phases. From basic information and the results of many breadboards, an engineering test unit was fabricated that looked somewhat like the final product; this unit was demonstrated to GSFC personnel. There were faults in the equipment; however, integration into the spacecraft was necessary to aid in the redesign effort. The unit was integrated into the appropriate spacecraft at MBB in Munich, West Germany. During testing at WTA and during integration at MBB, tests showed that the unit needed to be redesigned to meet the technical and compatibility requirements. The major areas requiring redesign were in the preamplifiers, log amplifiers, and detector.

Those circuits were redesigned and tested and the new designs were integrated into the system prior to the manufacturing of Prototype 1.

1.2.2 Prototype 1. The Prototype 1 Radiometer was constructed using the redesign resulting from the inadequacies noted in the ETU Test Program. The radiometer and preamps were delivered to GSFC for integration into the spacecraft. Mr. R. Weber, GSFC, supervised the installation into the spacecraft at MBB in West Germany during May 1973 - the unit worked in the spacecraft. The noise level in the spacecraft was not particularly high. All functions operated normally with the exception of one channel on the radiometer that failed during Thermal Vacuum Testing. During integration, MBB found that the circuit grounds and shield grounds were not completely separated; they are tied to each other with a 3.3 microfarad capacitor. The integration requirements required that there be no connection

between the grounds. It was later agreed that a .01 mfd capacitor should be used. This Prototype 1 unit was not changed but all other units were changed to .01 mfd.

1.2.3 Prototype 2. The prototype 2 radiometer and preamps were delivered to GSFC in May 1973 and integrated into the spacecraft at MBB in West Germany by WTA personnel in September of 1973. The unit worked well. The noise level was lower than on prototype 1. All channels and functions worked properly at the time of delivery; however, prior to launch, two oscillators failed.

1.2.4 Flight 1. The flight 1 radiometer was accidentally damaged during assembly by a Government representative. This damage resulted in one radiometer being left out of the unit. All other circuits and systems were operational. The unit was delivered with its preamplifiers to GSFC in March of 1974.

1.2.5 Flight 2. The flight radiometer and preamps were fabricated and tested and presented to GSFC for acceptance. The unit was rejected primarily because the oscillator (WTA manufactured) seals were suspect since some were found to be beyond the original specification limit. In addition, the flight 2 radiometer failed vibration tests five times, ground connections in the IF amplifier PC boards and one connection to the mixer were broken, and one connection on the radiometer was suspect. The connection was replaced, the connection to the mixer was repaired, and the grounds were repaired and strapped with jumper wires. The radiometer subsequently passed vibration and Thermal Vacuum Testing.

Flight 2 was integrated into the spacecraft and tested at MBB, West Germany during March 1975. WTA personnel were present and helped per-

form the testing. All functions worked properly. The noise levels in channels 13, 14, and 15 of both radiometers were higher than before integration; this was confirmed by comparing computer printouts of noise levels of Flight 1 to Flight 2. The noise levels on these two systems were comparable. MBB and GSFC personnel were notified of the facts. Integrated test data was delivered to GSFC personnel during March 1975.

SECTION 2

RADIOMETER SYSTEM

2.1 OPERATION OF SYSTEM

The Radiometer System is designed to operate in conjunction with an experiment computer know as the DPU. In its intended condition, all functions are controlled by the DPU.

Basically, a Radiometer system consists of two separate Radiometers, A and B, arranged so that one or the other can be commanded into operation. As the system is arranged, Radiometer B is always selected when power is initially applied to the Radiometer System. Additionally, two preamplifiers are connected to a dipole antenna system and so arranged that signals in phase to both antennas are cancelled and signals out of phase are processed by the Radiometer.

The Radiometer system is designed to process noise signals in the frequency band from 20 kHz to 3.00 MHz in 10 kHz wide increments. The tuning of the system is accomplished by switching the output of one of sixteen crystal-controlled oscillators in the mixer, thereby allowing the Radiometer to sample approximately 160 kHz of the band in 10 kHz segments.

The dynamic range of approximately 90 db is accomplished by automatically switching the gain of the preamplifiers in three, 30 db ranges. With this arrangement, the RF section of the Radiometer sees only a limited dynamic range signal, about 40 db.

The RF section operates at 21.4 MHz IF frequency and the local oscillator frequencies range from 21.4265 to 24.400 MHz. The exact frequencies are listed in table 2-1.

TABLE 2-1

RADIOMETER OPERATING FREQUENCIES

CHANNEL	CRYSTAL FREQUENCY	OPERATING FREQUENCY
1	21.4265 MHz	26.5 kHz
2	21.450 MHz	50.0 kHz
3	21.465 MHz	65 kHz
4	21.485 MHz	85 kHz
5	21.515 MHz	115 kHz
6	21.550 MHz	150 kHz
7	21.595 MHz	195 kHz
8	21.655 MHz	255 kHz
9	21.740 MHz	340 kHz
10	21.845 MHz	445 kHz
11	21.985 MHz	585 kHz
12	22.165 MHz	765 kHz
13	22.410 MHz	1.010 MHz
14	22.720 MHz	1.320 MHz
15	23.680 MHz	2.280 MHz
16	24.400 MHz	3.00 MHz

The signal presented to the DPU is a log-compressed analog voltage and a range flag consisting of two bits.

An internal non-redundant noise source can be switched by command into the preamplifier inputs and thereby effect an end-to-end system calibration.

The Radiometer System provides a temperature monitor and two monitor and two voltage monitor outputs, a ± 6 VDC monitor and a + 12 VDC monitor.

As a system, the radiometer operates in the following manner. A signal is picked up by the satellite dipole antenna and is presented to the preamplifier inputs. Since the received signal is assumed to be a noise function of some frequency distribution, only the 10 kHz wide portion around the operating frequency (the operating frequency is the difference between the local oscillator (LO) and the IF center frequencies) is processed. The Radiometer then amplifies the noise signal, detects it with an AM detector, and compresses it logarithmically. If the compressed output is within the operating range of about .5 to 4.5 volts, the signal and the indicated range are sent to the DPU. If the signal is outside these bounds, the Radiometer automatically selects the appropriate range and sends the proper command to the preamplifier to adjust its gain. There are three discrete gain positions of the preamplifiers, 0 db, +30 db, and +60 db gain. These gain settings are automatically adjustable and cannot be set in any position by external signals.

Upon command of the DPU, the Radiometer selects the designated LO frequency and will then process that selected noise spectrum and present a DC voltage in the range of .8 to 5.0 VDC to the DPU for further analysis and transmission from the spacecraft.

THEORY OF OPERATION

SECTION 3

3.1 SYSTEM BLOCK DIAGRAM

A block diagram of the Radiometer system is shown in figure 3-1. Minus gains refer to voltage losses.

3.1.1 Preamp. Signals from the antennas enter the preamplifiers through the 0 db input stage, the purpose of which is to effect an impedance transformation from the very high antenna impedance to the lower levels used in the amplification circuitry. The preamplifier input impedance is approximately 10 megohms at very low frequencies with approximately 7.5 pf differential input capacitance.

Attenuator No. 1 attenuates the signal at either 10 db or 40 db depending on the state of the command from the Radiometer. Following this is an identical stage of attenuation and gain. The output of the second 40 db amplifier drives a buffer amplifier that connects the output to a balanced 50 ohm output to drive the combined load of the interconnecting cable and the Radiometer input balun.

The signals from the two preamplifiers are "subtracted" in the balun and, since the desired inputs are out of phase, the signal in the secondary of the balun is then the vector addition of the two preamplifier outputs. Each preamplifier has a relay in the input to switch in a calibration signal from the Radiometer.

3.1.2 Balun. The balun provides a means of operating either Radiometer without the need for an elaborate switching network. The signal from the preamplifiers is always equally divided between the two Radiometer inputs.

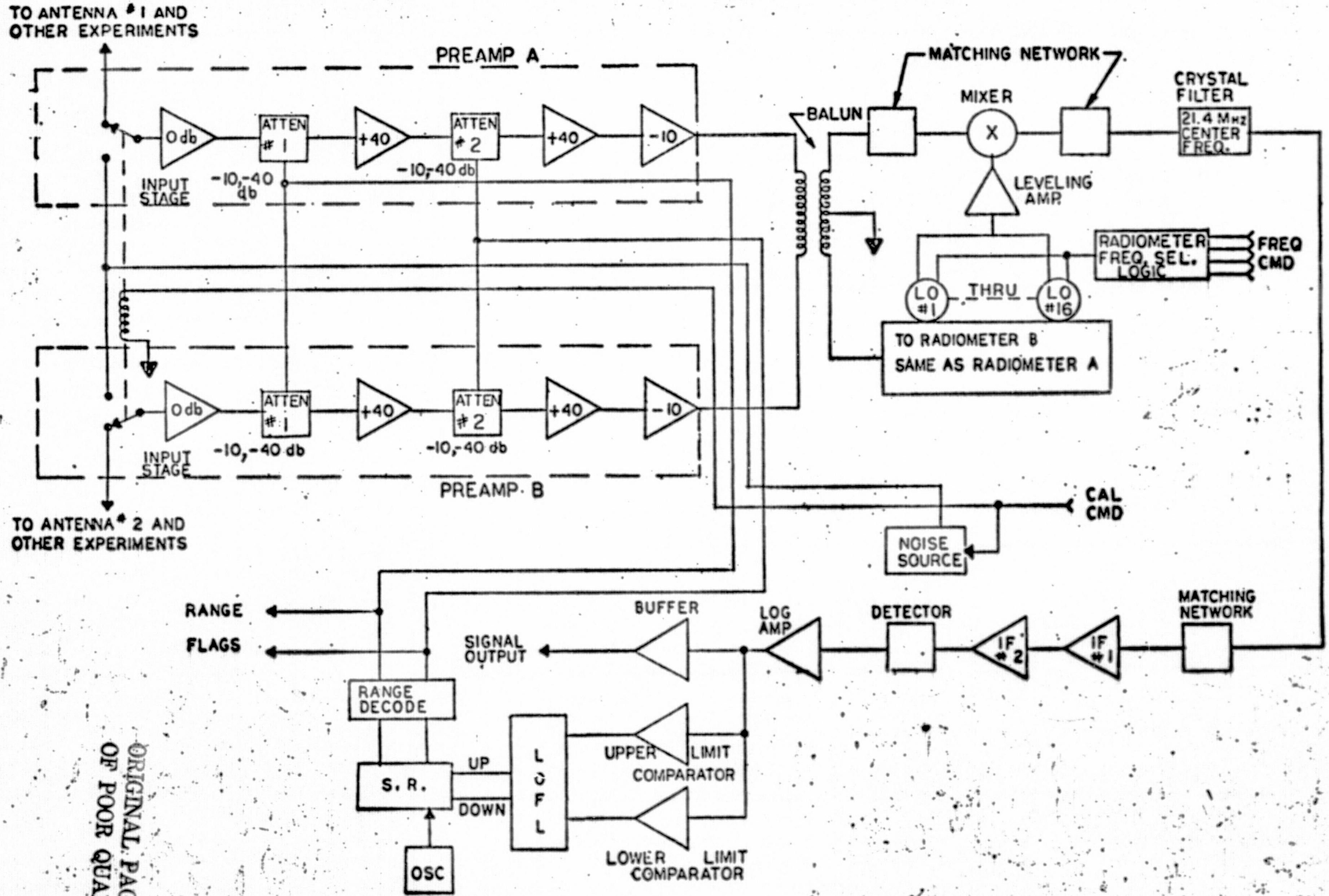

Figure 3-1. System Block Diagram

3.1.3 Mixer Local Oscillator. Following the balun is a matching network to provide the necessary impedance transformation between the balun and the mixer. The mixer provides the non-linear element necessary to convert the input to the 21.4 MHz IF frequency. The local oscillator provides the offset frequency. The outputs of all 16 oscillators are connected in parallel but only one has power applied to it through the Radiometer frequency select logic. This common bus is applied to the mixer through a leveling amplifier which provides a constant level to the mixer regardless of the output level of the oscillator. This circuit arrangement reduces the requirements on the amplitude tolerance and the stability of the oscillators.

3.1.4 Crystal Filter. The output of the mixer is coupled into the matching network and then into the 10 kHz wide crystal filter which has a center frequency of 21.4 MHz. These two frequencies were specified by GSFC.

3.1.5 IF Amplifier. Following the crystal filter is another matching network followed by two IF amplifiers, each consisting of a Motorola MC 1552 integrated circuit amplifier and its associated components.

3.1.6 Detector - Log Amp. The detector which follows the second IF amplifier is an averaging detector using a current biased detection diode. The output of the detector is a linear function of input power. The desired output is a logarithmic function of input power; therefore, a logarithmic amplifier is utilized to create an output voltage that is representative of power in db's. The output of the log amplifier is buffered and sent to the DPU.

3.1.7 Output. The output of the Radiometer is constrained at the upper limit by the +6 volt power supply and at the lower limit by the threshold noise (-0.25V). This threshold is established by adjusting the IF gain to provide a noise floor that represents a positive output of approximately 100 to 200 millivolts at Channel 1 frequency. This threshold reduces to about 50 to 100 millivolts at Channel 16. This frequency roll-off is due primarily to the RC characteristics of the preamplifier input circuitry.

3.1.8 Range Control Methods. The output of the log amplifier is also connected to the range control circuitry which consists of an upper and lower limit comparator, logic, shift register, oscillator, and range logic. Depending on the state of the comparators, a signal is sent to the shift register to shift to a higher or lower range, or do nothing, which happens in the case where the output signal of the log amplifier is greater than +0.5 volts and less than +4.5 volts. If that level exceeds +4.5 volts, a signal is generated that causes the shift register to advance in the direction that decreases the preamplifier gain. Conversely, if the signal dips below +0.5 volts, the shift register moves in the direction necessary to increase the gain. When the logic ranges to either the maximum or minimum gain and the output signal is still outside the above bounds, the logic stops operating and the unit remains in the higher or lower state.

3.1.9 Noise. The noise source is commanded "on" by an external command from the DPU. Upon command, the noise source power is applied and the two preamplifier relays switch the noise signal into the preamplifier input and disconnect the antenna inputs. The noise is broad band and covers the desired frequency range of 25 kHz to 3 MHz.

3.2 RADIOMETER REDUNDANCY

The radiometers, "A" and "B", are commanded "on" at a time. Radiometer "B" will "on". After approximately 30 seconds (the time required to charge a capacitor), radiometer "A" can be commanded "on" or the system can be left in channel "B" mode.

3.2.1 Circuit Description . Each circuit of the radiometer is discribed; with the description is a circuit diagram and a photograph of one of the prototype or flight units.

3.2.2 Preamplifier Circuit Description. The preamplifier is supplied with ± 6 VDC power from the power relay. The input is connected (see figure 3-2) to either the antenna or noise source by relay K1. Input resistor R_{50} is normally 2K; the resistor is mounted on standoffs so that it can be changed to some other value if desired. The signal is buffered by a F.E.T., Q_1, in a bootstrap circuit, so that the input circuit appears as many meg ohms shunted by approximately 7.5 p.f. The output of the F.E.T. presents a low impedance to the lst gain change network. Q_2 and Q_3 help to stabilize the output of Q_1 over its full operating voltage range. The network C_6, C_9, C_{42}, C_{10}, C_{11}, C_{13}, R_{12}, R_{16}, R_{17}, and R_{18} make up the gain changing pad. When Q4 is "off" the gain is -10 db and when Q_4 is "on" the gain is -40 db.

The output of the gain changing pad #1 is connected to amplifier Z_1. No. 2 is an operational amplifier with compensating components designed to reduce temperature effects on the amplifier. The gain of Z_1 is 40 db.

The output of Z_1 is attenuated by the second gain changing pad. This pad is like the first one. Gain change is accomplished by operating Q_5. The signal is attenuated by either 10 db or 40 db depending on the state of Q_5.

The output of Z_2 is amplified and attenuated by a wide range high level amplifier,

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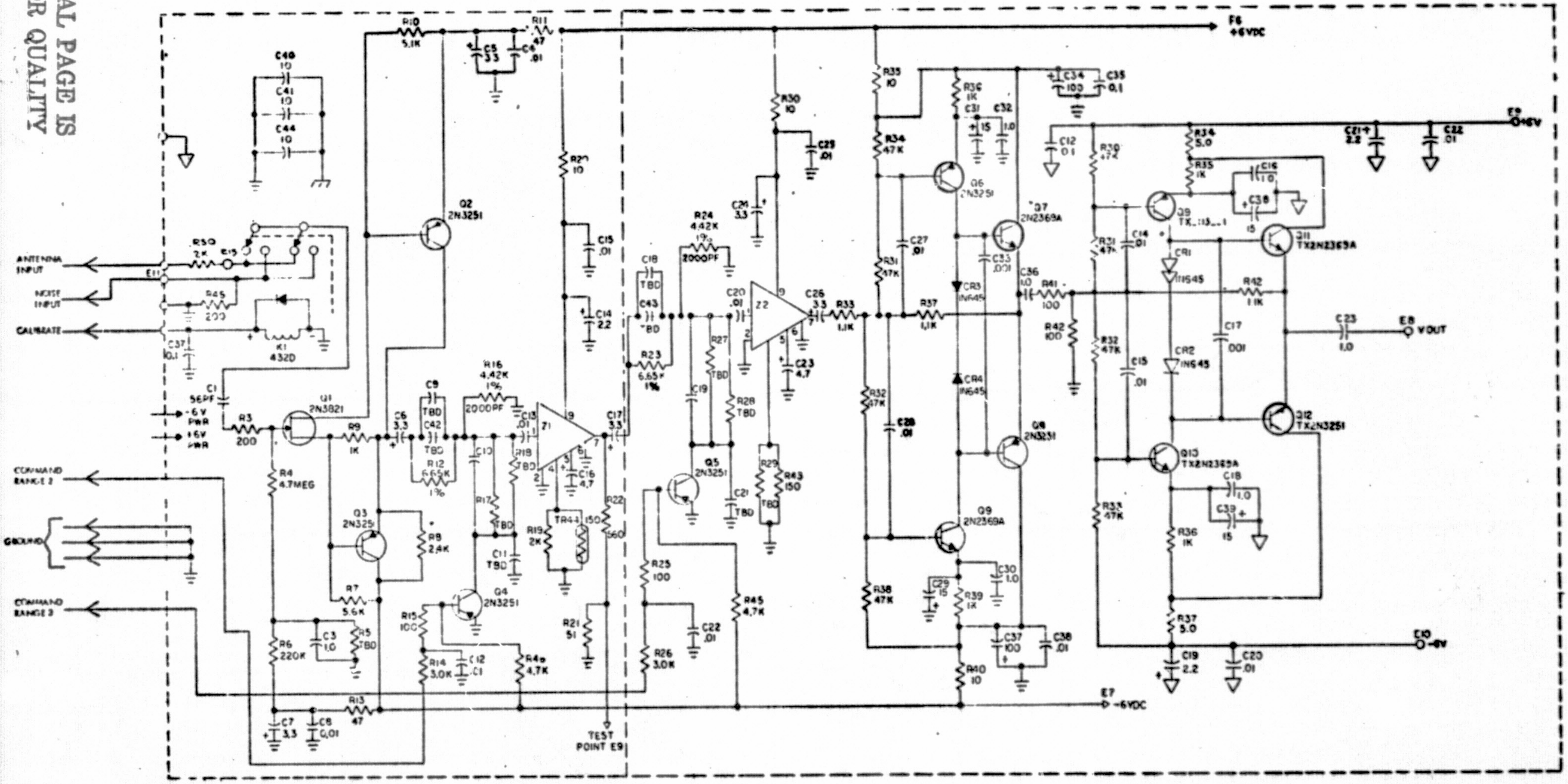

Figure 3-2. Schematic Diagram, Preamplifier (PC 716)

Q_6, Q_7, Q_8, Q_9, Q_{10}, Q_{11}, and Q_{12}. The net result is a linear amplification in 3 ranges of +50 db to -40 db that is flat from 25 kHz to3 MHz and provides a 50 ohm output to the coax cable that feeds the balun.

The preamplifier is packaged on 2 printed circuit boards and housed in a GFE box. Figures 3-3, 3-4, 3-5 show each board and installation in the box, respectively.

3.2.3 Balun, Mixer and Crystal Filter Circuit Description. Balanced signals from each preamplifier are supplied to the balun T_1. The input to the balun is resistively matched to the 50 ohm coax to effect maximum power transfer.

Each preamp feeds the balun 180° out of phase, with respect to the opposite preamplifier, so that only those signals or components that are 180° out of phase at the preamp inputs will be amplified. Signals in phase will be cancelled. The physical arrangement of the balun is shown in figure 3-6. The balun transformer and matching resistors are contained on a single PC board #PC732. (figure 3-7)

This output of the balun is sent unbalanced to either radiometer A or B. This output is reactively matched to the balanced mixer M. The output of the mixer is reactively coupled to the crystal filter. Since the filter impedance is high (i.e. 750 ohm), an auto-transformer tuned with C_{49} and C_{25} provides the matching at 21.4 MHz.

The operation of the mixer is such that a local oscillator input of constant amplitude and selectable frequency is mixed with the input to produce a 21.4 MHz ±5 kHz output. The input frequencies range from 25.5 kHz to 3 MHz. The local oscillators are on the high side and range from 21.4265 MHz to 24.4 MHz. Since the input is quasi-random noise, the output is a noise spectrum that is flat at least over the 10 kHz of interest. The physical arrangement of the mixer and its associated components is shown in figure 3-8; all components are mounted on a PC board #PC 721.

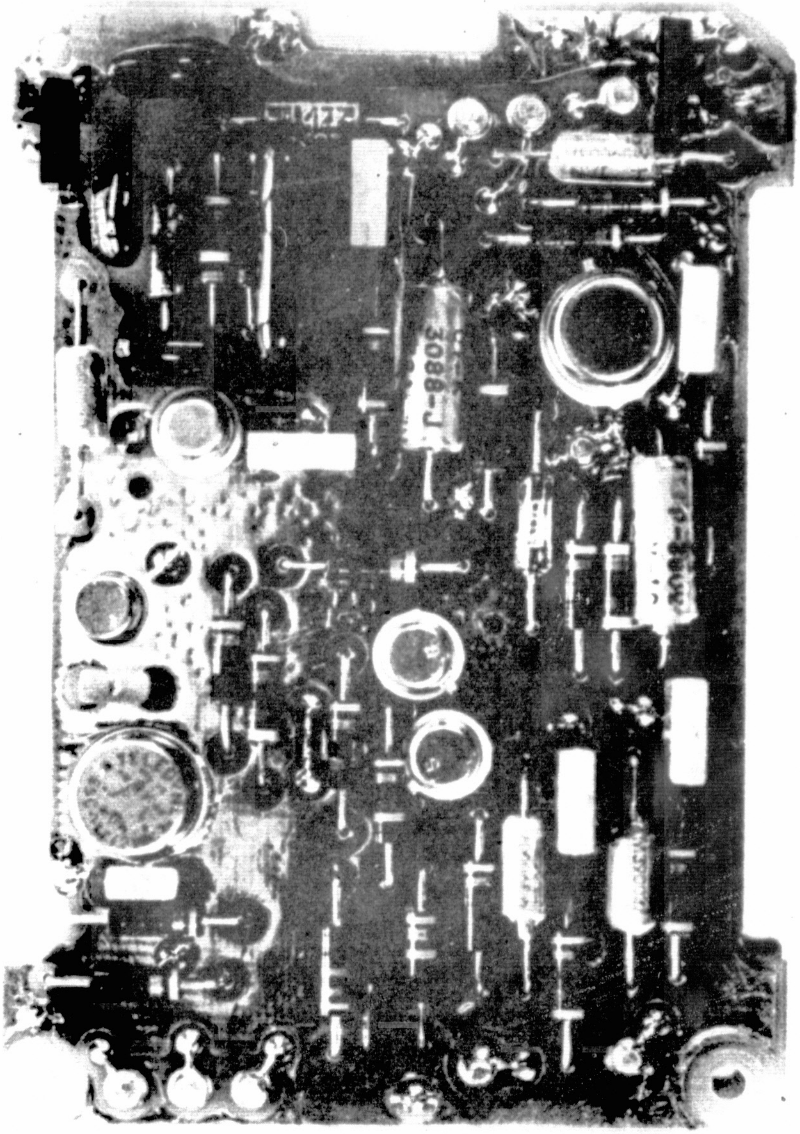

Figure 3-3. Component Location, Preamplifier Board 1

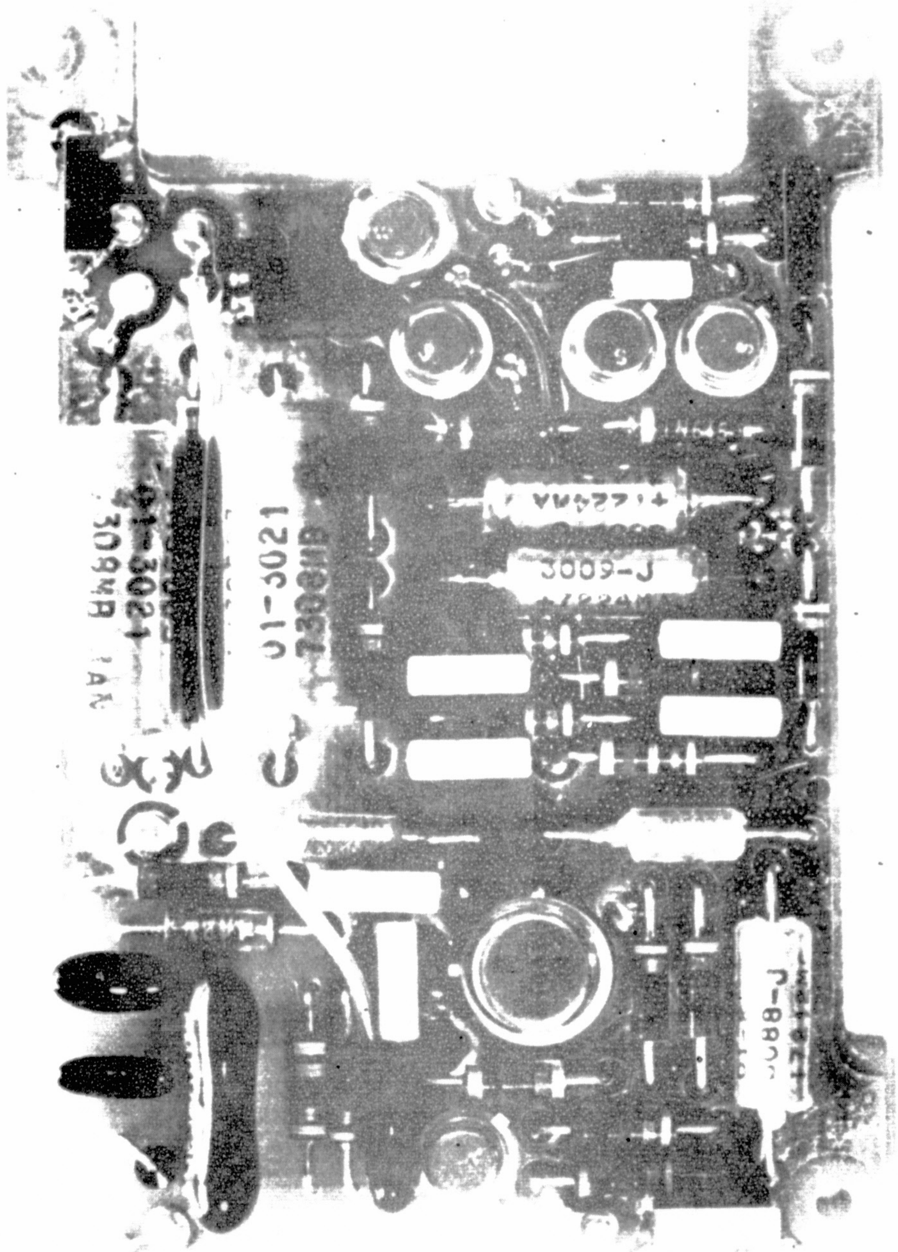

Figure 3-4. Component Location Preamplifier Board 2

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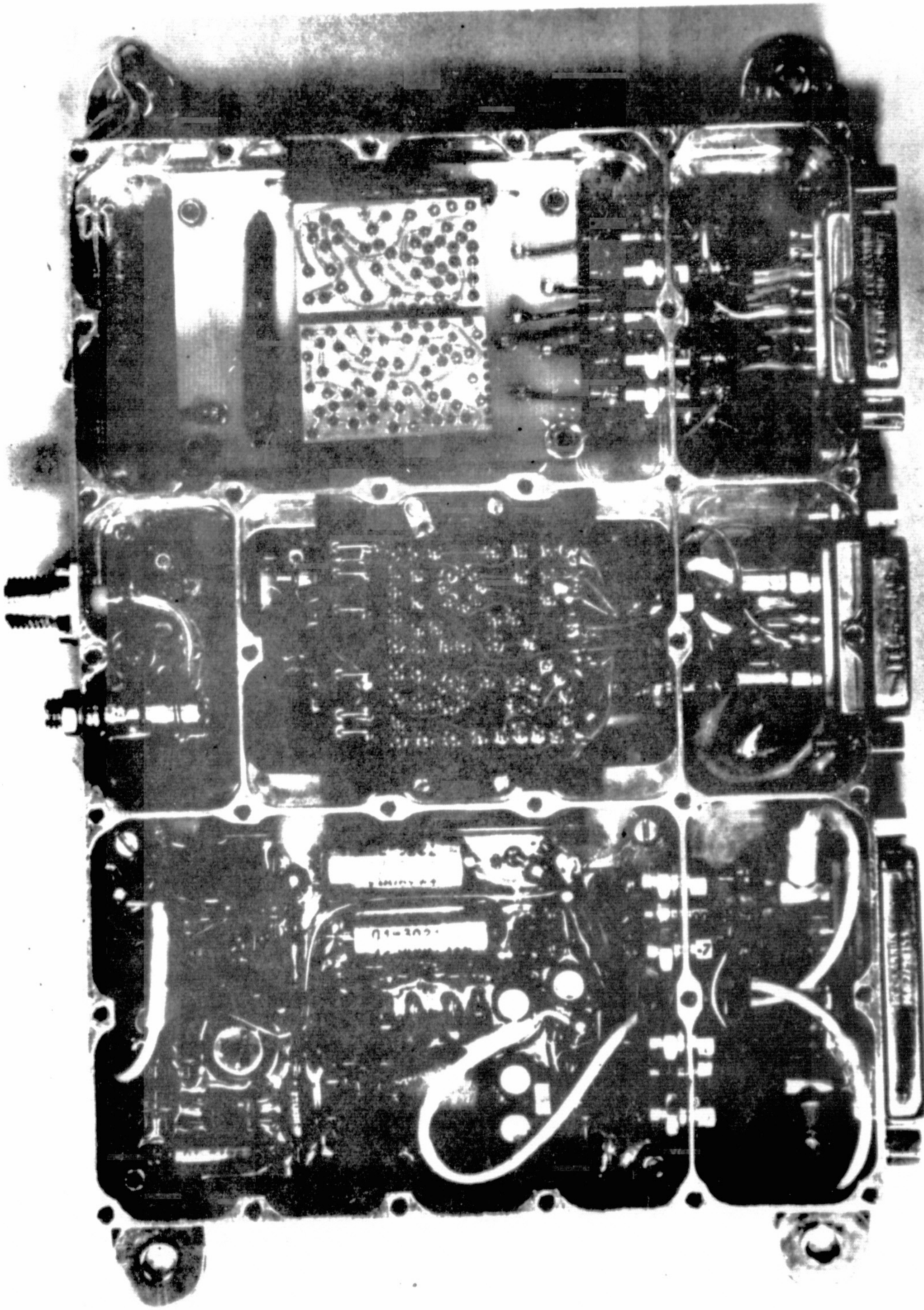

Figure 3-5. Preamplifier Boards 1 and 2 Installed

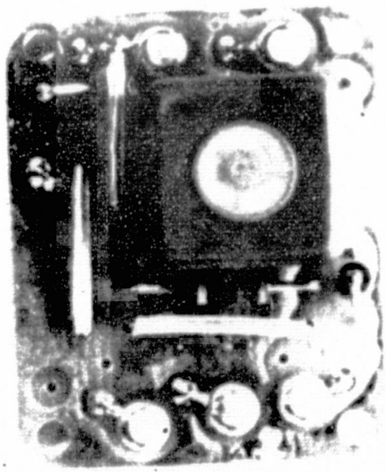

Figure 3-6. Component Location, Balun (PC 732)

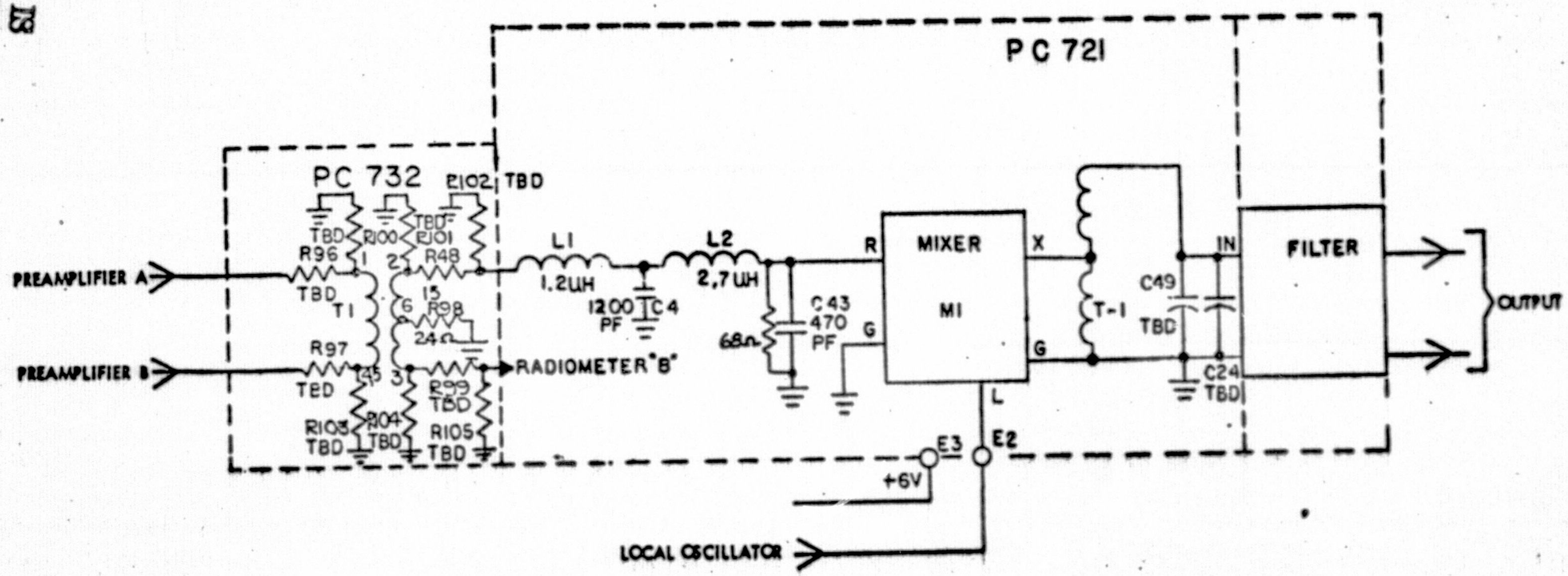

Figure 3-7. Schematic Diagram (PC 732), Mixer (PC 721), and Crystal Filter

Figure 3-8. Component Location, Mixer (PC 721)

The filter is a monolythic crystal filter manufactured by Reeves Hoffman in Mt. Holly, Pa. The unit has a 10 kHz band width and steep slopes on each side of the bandpass. These characteristics of the filter are only realized if the input and output are properly matched to 750 ohms. This matching is done in the mixer board and in the IF amplifier board. The crystal filter is shown in figure 3-9.

3.2.4 IF Amplifier Circuit Description. The IF amplifier operates at 21.4 MHz and provides enough gain to properly operate the detector. As previously mentioned, the input must provide an impedance of 750 ohms for the crystal filter. This is accomplished by L_4, C_{50}, and R_{23}. The signal is amplified by two cascaded amplifiers, A_3 and A_{19}; these amplifiers are Motorola MC 1552 units externally compensated to be stable over the required temperature range. The unit is contained on a single PC board #PC 784 (see figure 3-10). The schematic diagram is shown in figure 3-11.

3.2.5 Detector Circuit Description. The detector works well when detecting a signal composed of mostly noise. The input (see figure 3-12) is matched to Q_{20} by the capacitors C_{25} and C_{26} and the choke L_6. Proper bias is provided by a resistor divider network. The undetected signal, i.e. 21.4 MHz, is amplified by Q_{20} and further amplified by Q_{21}. Resistor R_{29} provides negative feedback to energize and stabilize the amplifiers. The amplifiers are tuned by an LC tank circuit. Tuning is accomplished by spreading or compressing the turns on the toroids (L_5, L_6, L_7). The output is detected by diode CR_4 and supplied as a DC voltage at the output. The unit is located on PC #785 (see figure 3-13).

3.2.6 Log Amplifier Circuit Description. A log amplifier is used to produce an output that is the logarithm of the input. The input operates from 4 millivolts to 500 millivolts and produces an output that varies from 1V to 5V. The log action is provided in the feedback loop of A_7 (see figures 3-14 and 3-15).

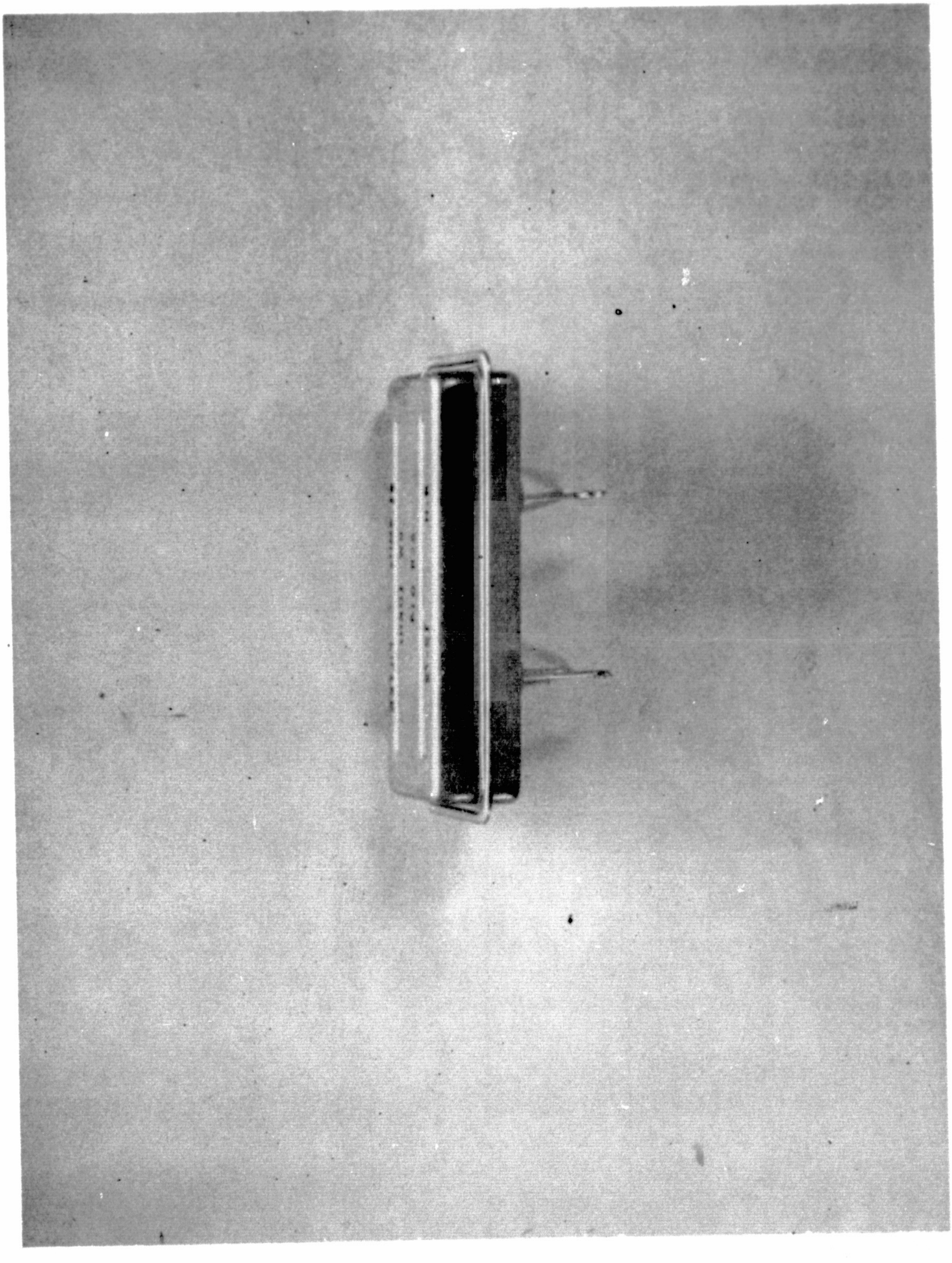

Figure 3-9. Component Location, Crystal Filter

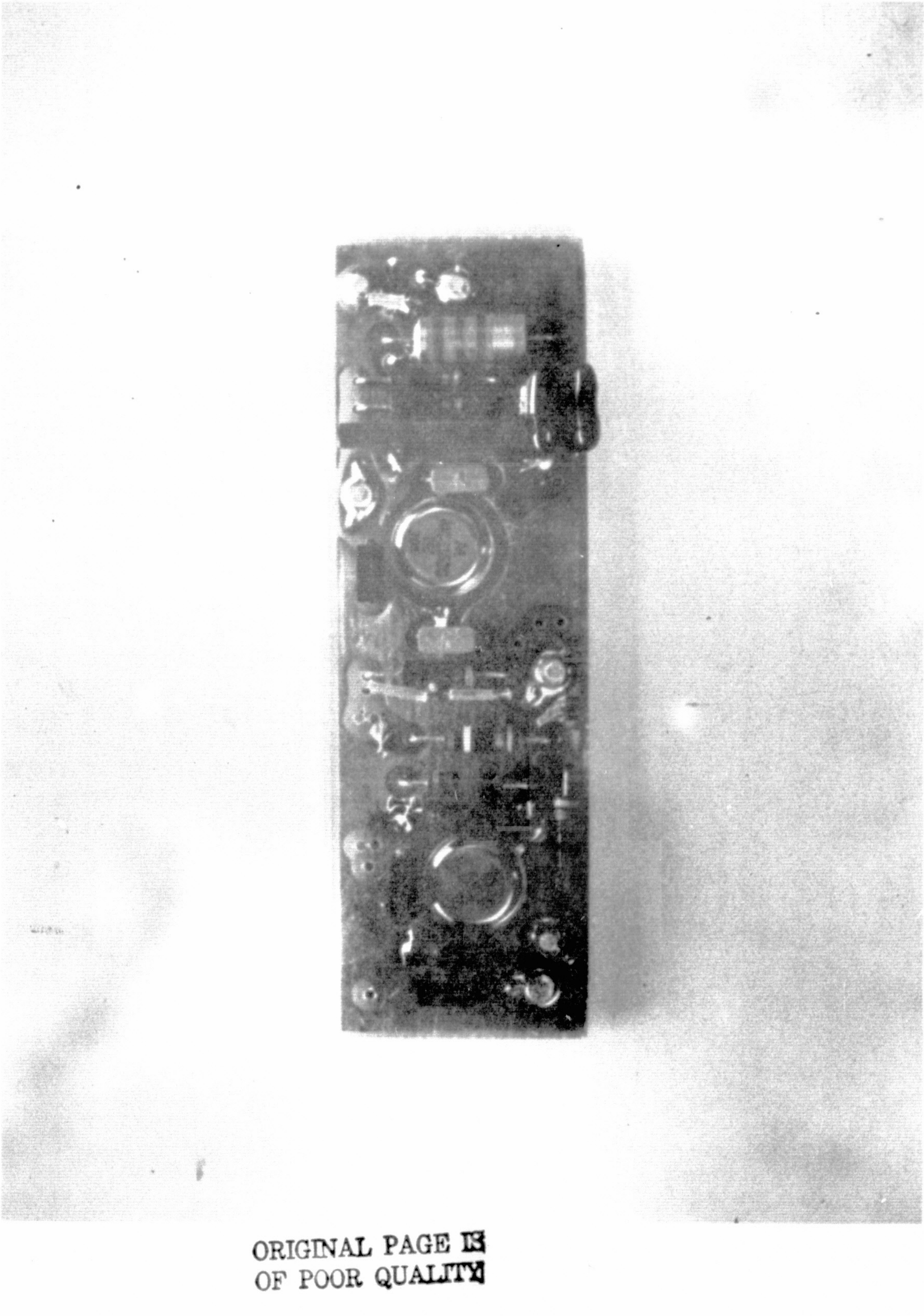

Figure 3-10. Component Location; IF Amplifier (PC 784)

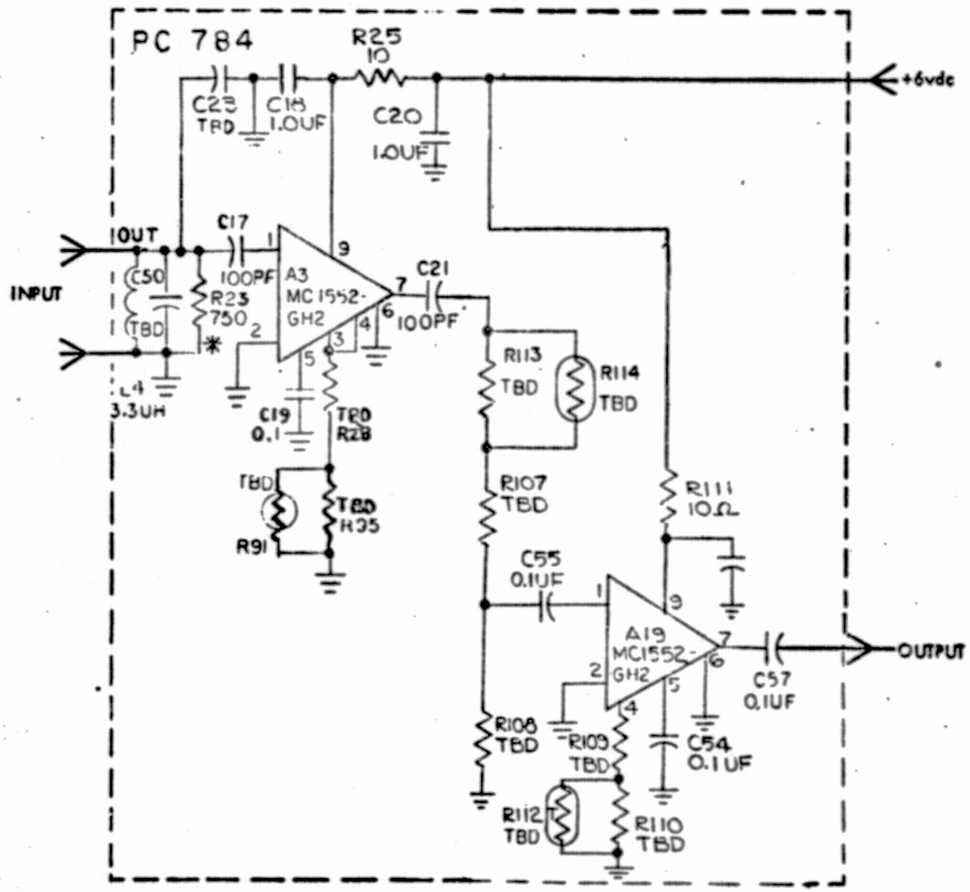

Figure 3-11. Schematic Diagram, IF Amplifier (PC 784)

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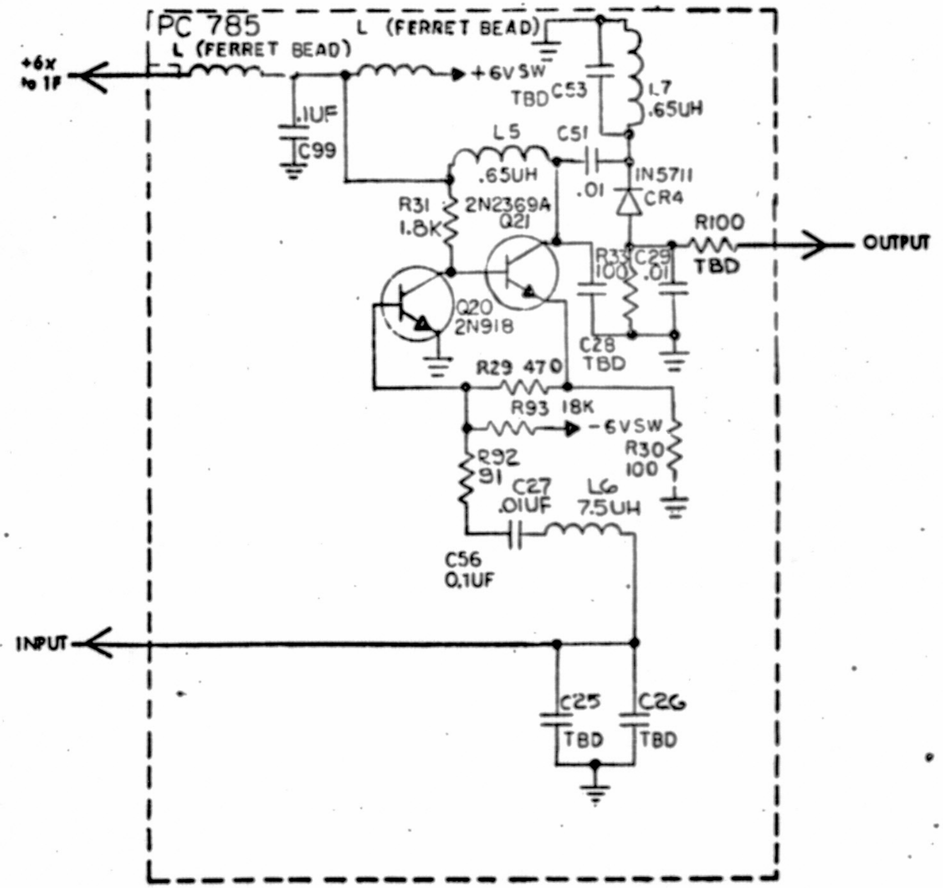

Figure 3-12. Schematic Diagram, Detector (PC 785)

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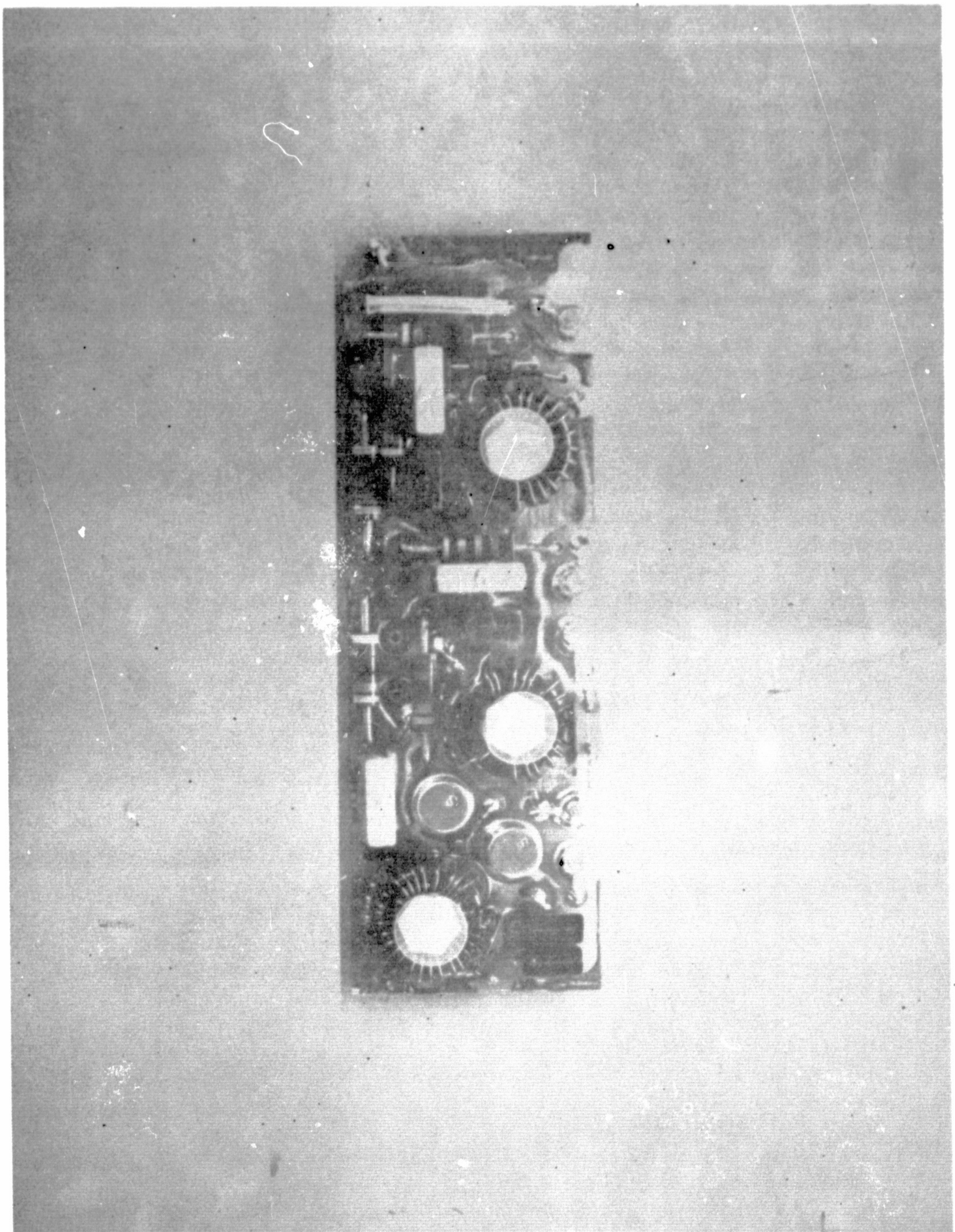

Figure 3-13. Component Location, Detector (PC 785)

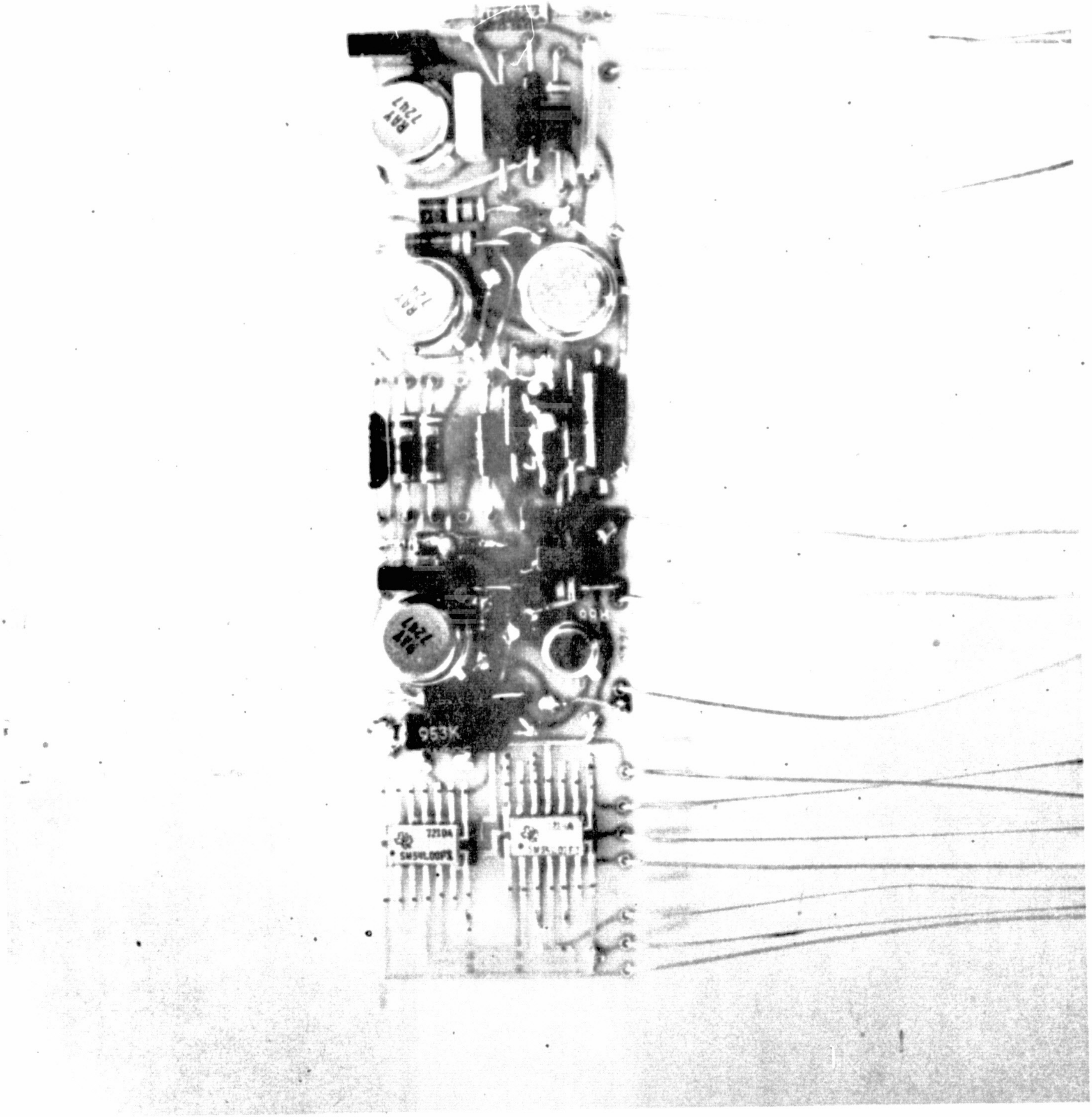

Figure 3-14. Component Location, Log Amplifier (PC 729)

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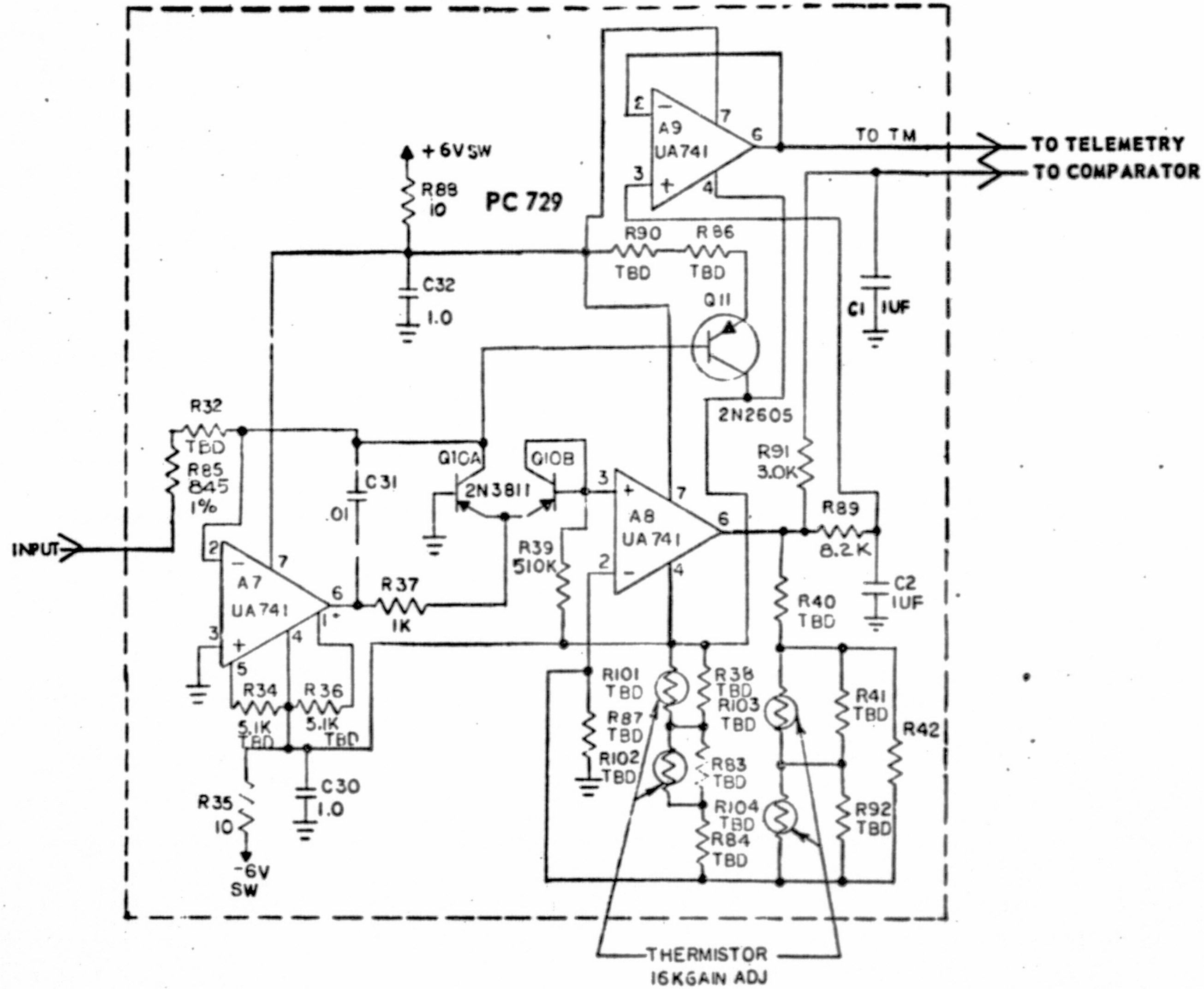

Figure 3-15. Schematic Diagram, Log Amplifier (PC 729)

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The input is coupled into the inverting input of the amplifier through R_{32} and R_{85}. Offset correction is provided by R_{34} and R_{36}; these resistor values are determined at test and are normally 5.1 ohms. Transistor Q_{10A} is in the feedback path of A_7. The base emitter junction becomes a feedback resistor whose resistance is the log of the current flowing through it. Transistor Q_{11} helps to make the transfer characteristic exactly logarithmic. The output voltage is therefore the log of the input voltage. The other half of the transistor Q_{10B} is used as a diode to compensate for the residual effect of Q_{10A}. Amplifier A_8 provides a convenient place for temperature compensation. The TBD thermistors are chosen to provide offset (or drift) stability (R_{101}, R_{102}) and gain stability (R_{103}, R_{104}).

The output of A_8 is delayed by a 3 ms time-constant and is connected to the range logic. The same output is also delayed by 8 ms and is supplied to telemetry via a unity gain amplifier A_9. Both outputs are a log representation of the input.

3.2.7 Range Switching Circuits Description. Range switching circuitry is arranged on PC boards 727, 728 and 726. Since operation of all the circuits is interrelated all will be discussed together (see figures 3-16, 3-17, 3-18 and 3-19). The input to the comparator is connected to pins 3 and 2 of A_{17} and A_{18} respectively. These amplifiers are connected as comparators and biased at +.8 volts for A_{18} and +4.5 volts for A_{17}. When the voltage increases above +4.5 volts (up range condition), a positive spike occurs on its output and tells the logic to increase. When the voltage falls between 4.5 volts and .8 volts the output is a negative spike which does not operate the logic. When the voltage decreases below +.8 volts, a positive spike is produced from A_{18}; this tells the logic to decrease. Selection of R_{65}, R_{66} and R_{67} is made to assure that 2 db or more of hysterisis is provided to keep the system from oscillating from one range to the other. The logic transformation is done in integrated circuit numbers A_9, A_{10}, A_{11}, A_{12}, A_{13}, A_{14}, A_{15} and part of A_{16}. Two of the gates of A_{16} are

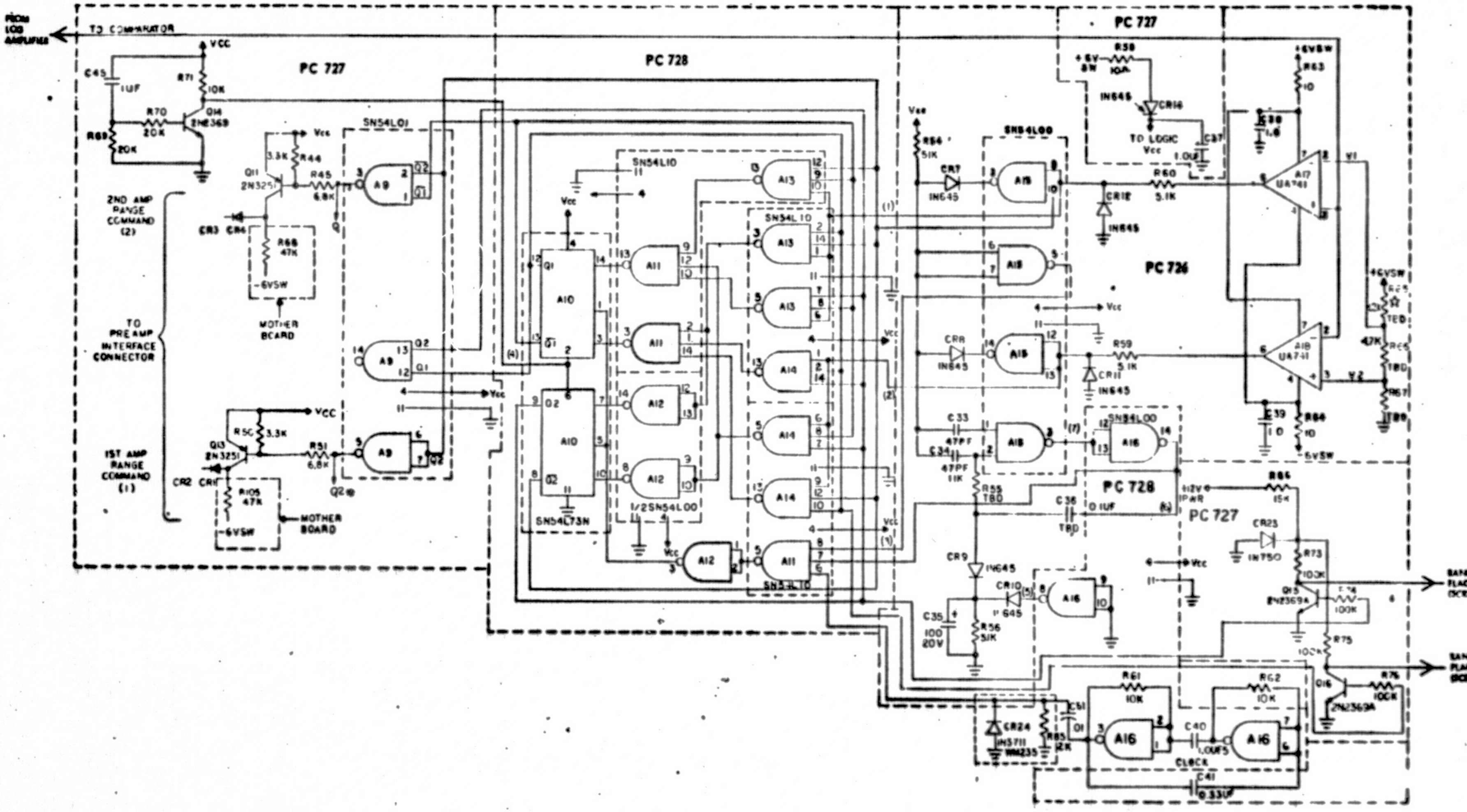

Figure 3-16. Schematic Diagram, Range Switching Circuitry (PC 726, PC 727, PC 728)

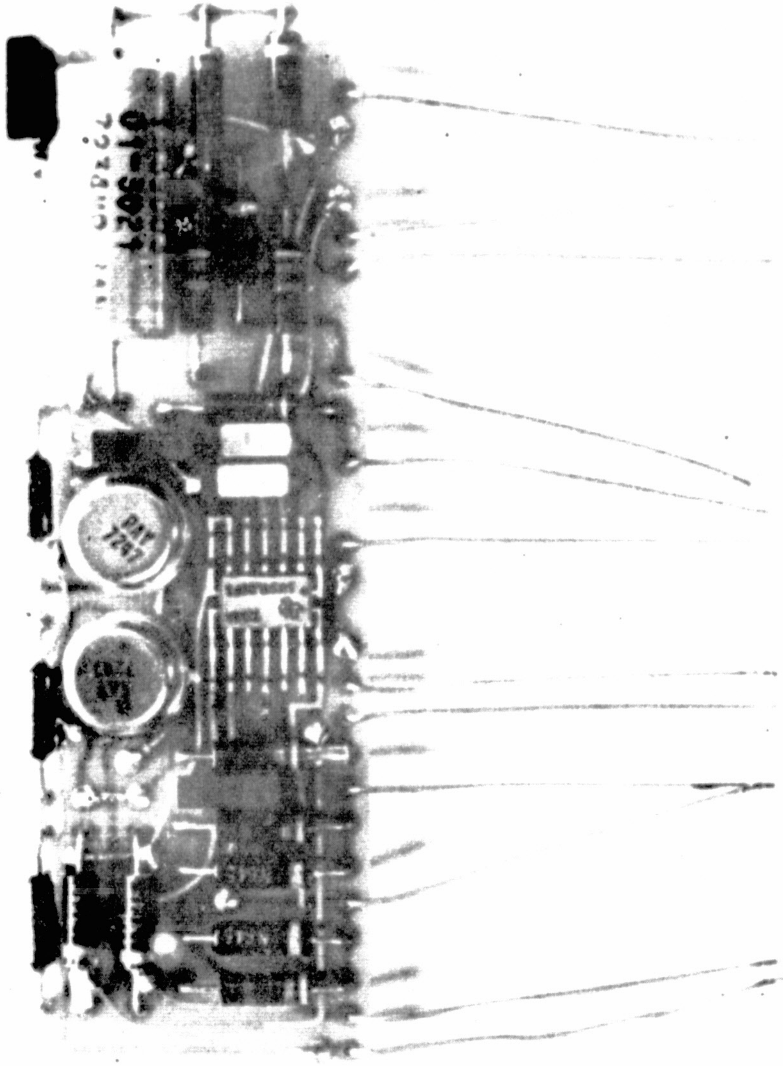

Figure 3-17. Component Location, Range Switching Circuitry, Logic 1 (PC 726)

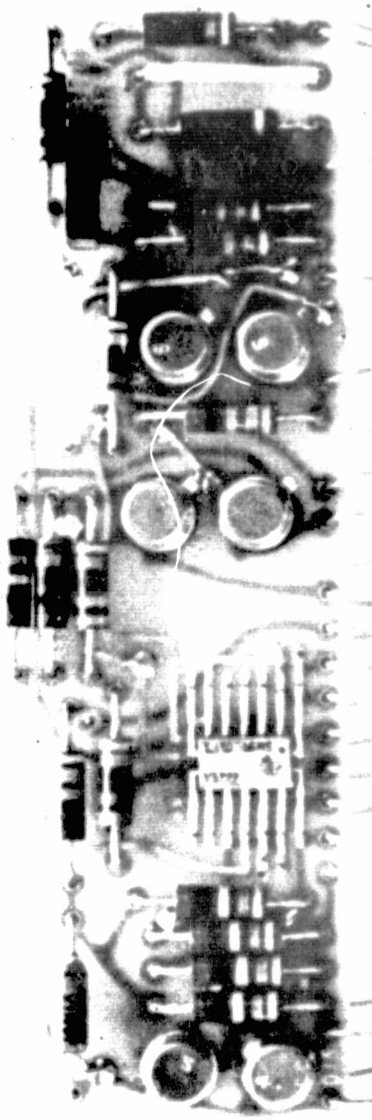

Figure 3-18. Component Location, Range Switching Circuitry, Logic 2 (PC 727)

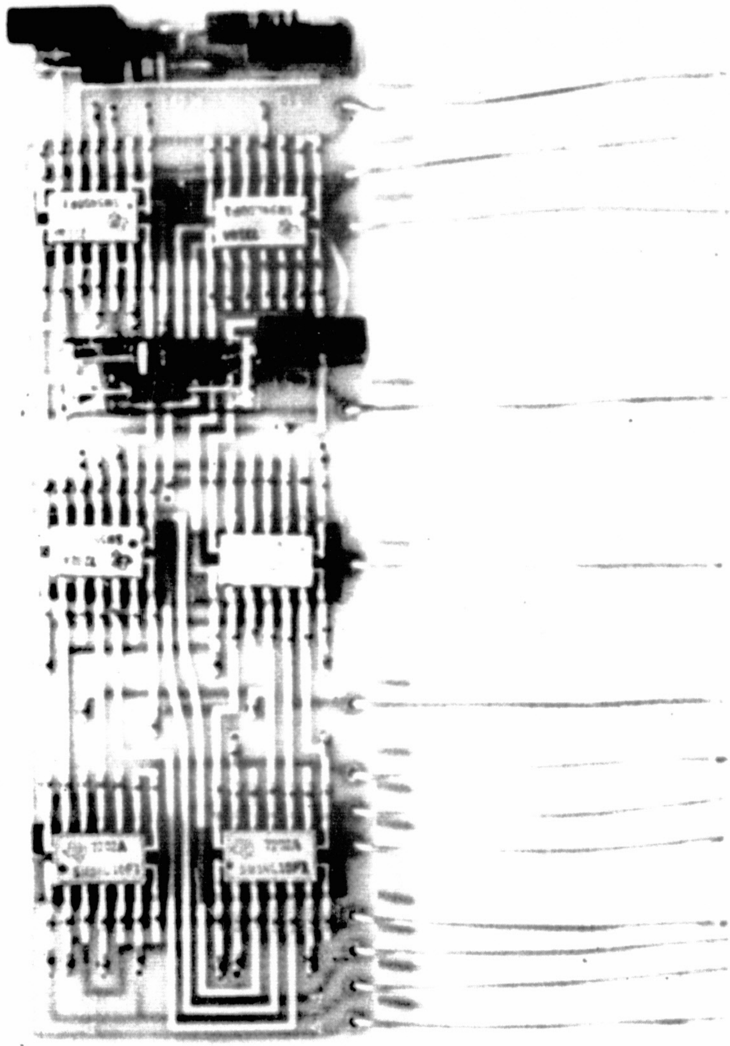

Figure 3-19. Component Location, Range Switching Circuitry, Logic 3
(PC 728)

used as a clock to control the logic. The A_{15} gates are input gates; A_{11}, A_{12}, A_{13} and A_{14} provide non-ambiguous output to the counter A_{10}. The range outputs are buffered by A9 and connected to the telemetry range flags and preamps to provide range switching.

3.2.8 Oscillator Circuit Description. Local oscillator power for the mixer is provided by 16 identical oscillators timed by a separate crystal for each channel. The oscillator frequencies are shown in table 3-1.

All oscillators are the same and are packaged in flat packs using hybrid circuitry. The circuit is shown in figure 3-20. The gate transistor Q_1 controls the operation of the oscillators. The oscillator transistor, Q_2 is tuned by an external crystal and the tank circuit L_1, C_3, C_4 and C_5.

The oscillators are connected together as shown in figure 3-21. Component location is shown in figure 3-22. All outputs are common. Logic inputs to operate the oscillators one at a time are the C and D inputs plus the gate input for each oscillator, 1 through 16. To operate, the oscillator must have +6 volts and ground applied through a proper combination of C and D and the gate for the oscillator must be turned "on".

The logic for turning "on" the oscillators is shown in table 3-1. The circuitry is located on the log amp board No. 729 (see figure 3-24).

The logic table for the oscillators is shown on the following page.

TABLE 3-1

OSCILLATOR LOGIC TABLE

Channel	A	B	C	D
1	1	1	+	+
2	0	1	+	+
3	1	0	+	+
4	0	0	+	+
5	1	1	0	+
6	0	1	0	+
7	1	0	0	+
8	0	0	0	+
9	1	1	+	0
10	0	1	+	0
11	1	0	+	0
12	0	0	+	0
13	1	1	0	0
14	1	0	0	0
15	0	1	0	0
16	0	0	0	0

3.2.9 AGC Amplifier Circuit Description. The outputs of all 16 oscillators are tied together at a common point. The AGC amplifier takes this output and provides a constant input level to the mixer. The circuit is shown in figure 3-25. Component arrangement is shown in figure 3-26. The input is amplified at its operating frequency of 21.265 MHz to 24.4 MHz and, detected by diode CR_3, CR_4, amplified by A_2, and fed back to a FET connected as a

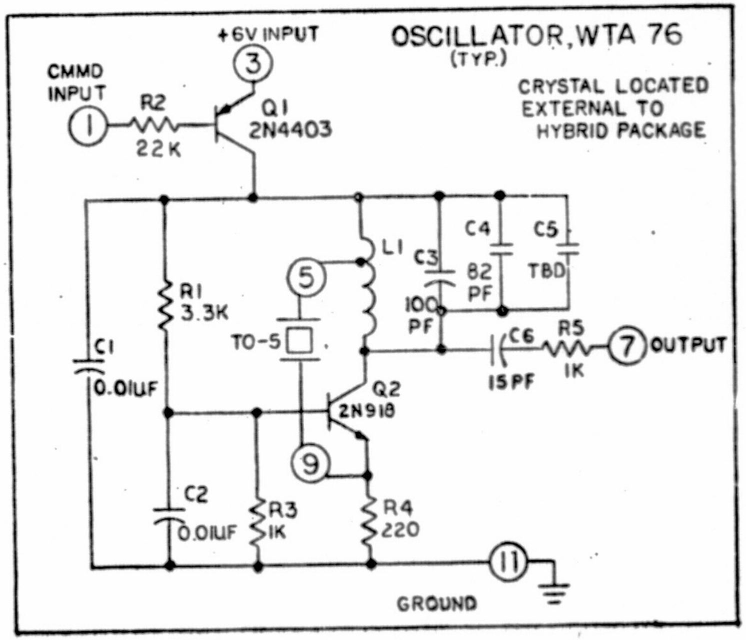

Figure 3-20. Schematic Diagram (Typical) Oscillator
(WTA 76)

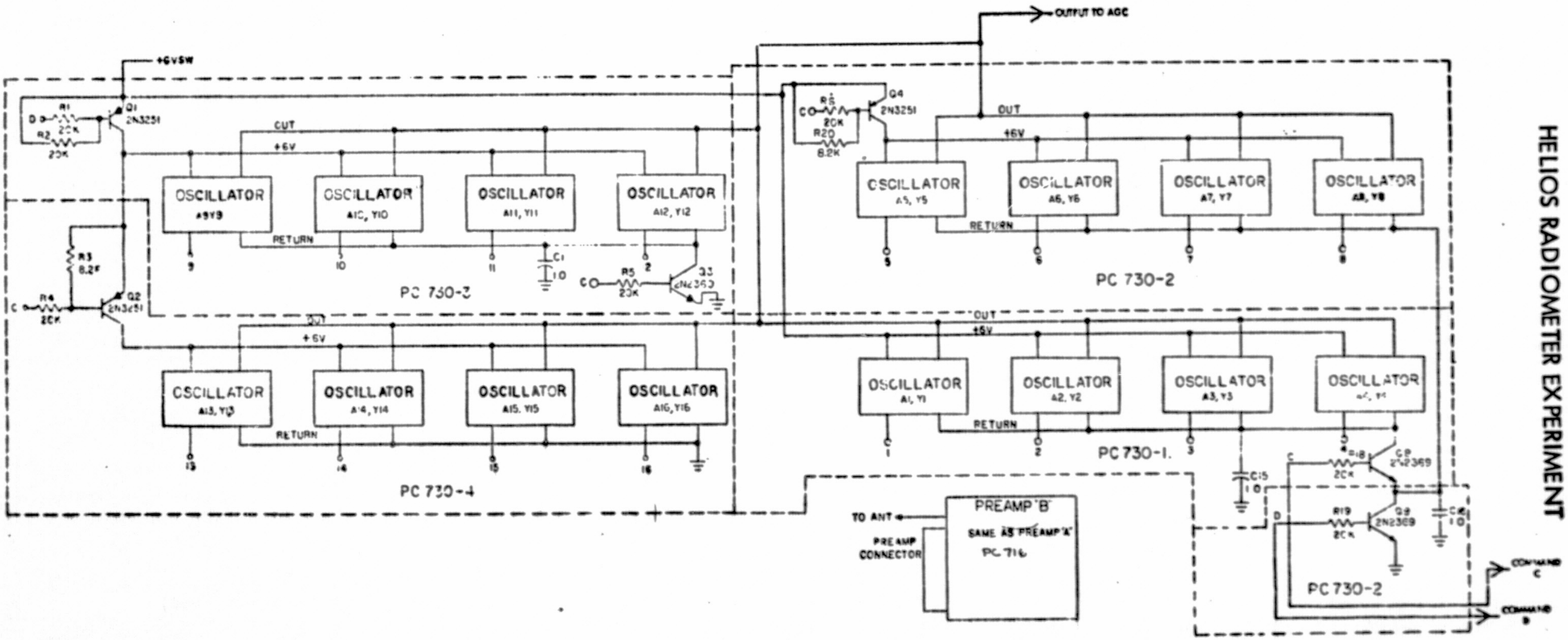

Figure 3-21. Block Diagram, Oscillators (PC 730-1, -2, -3, and -4)

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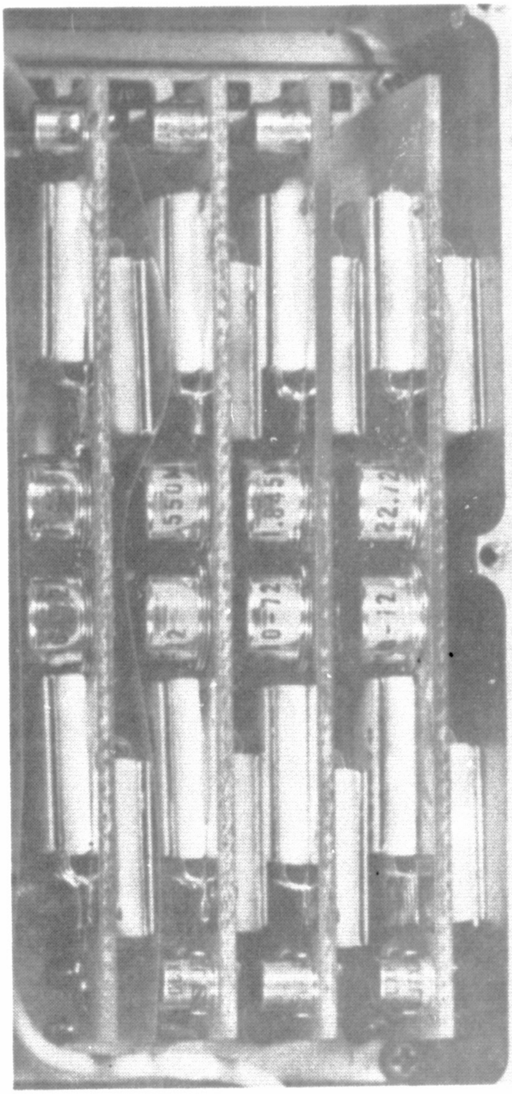


Figure 3-22. Component Location, Oscillator
(730-1, -2, -3, -4)

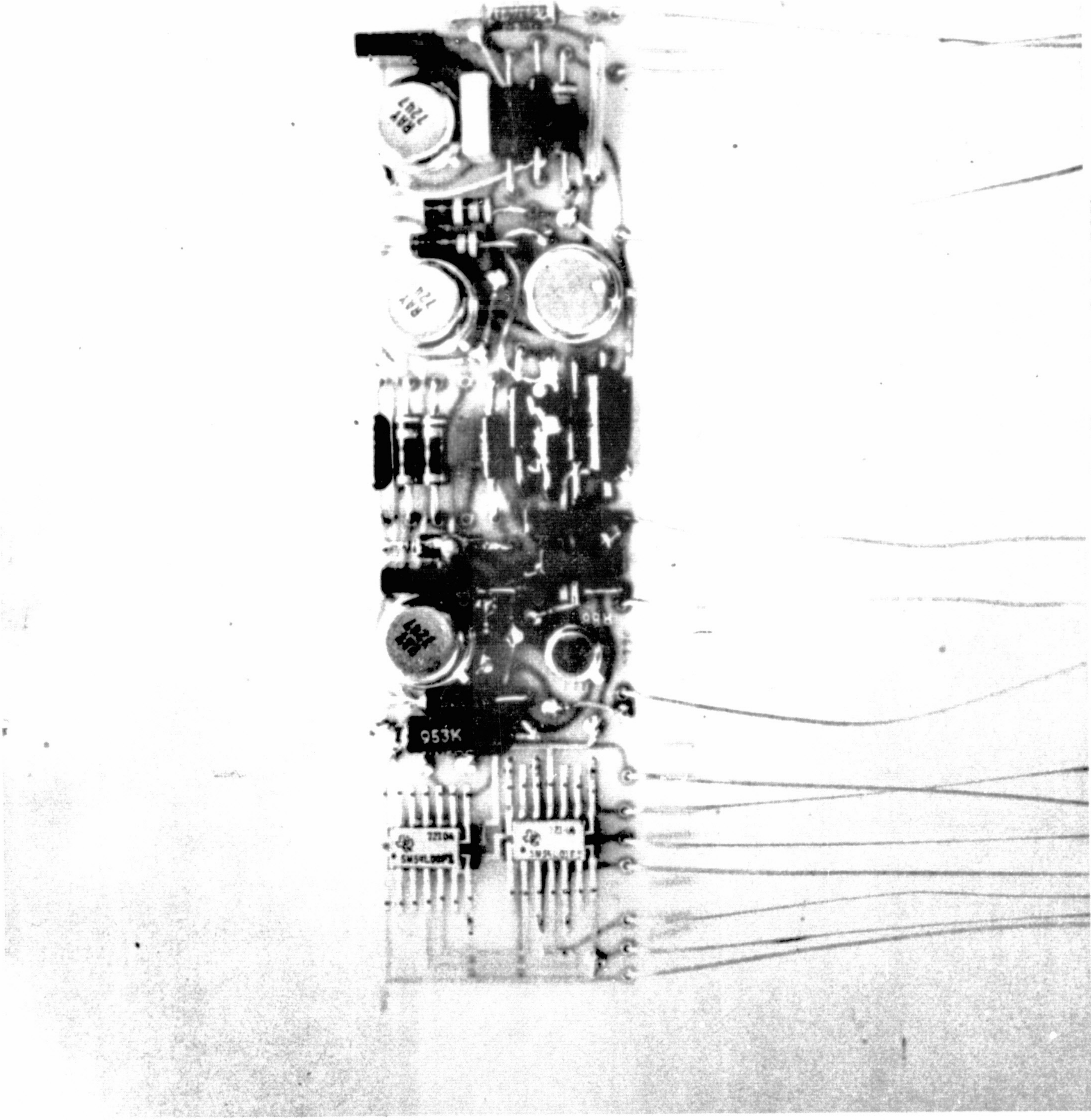


Figure 3-23. Component Location, Oscillator Switch (PC 729)

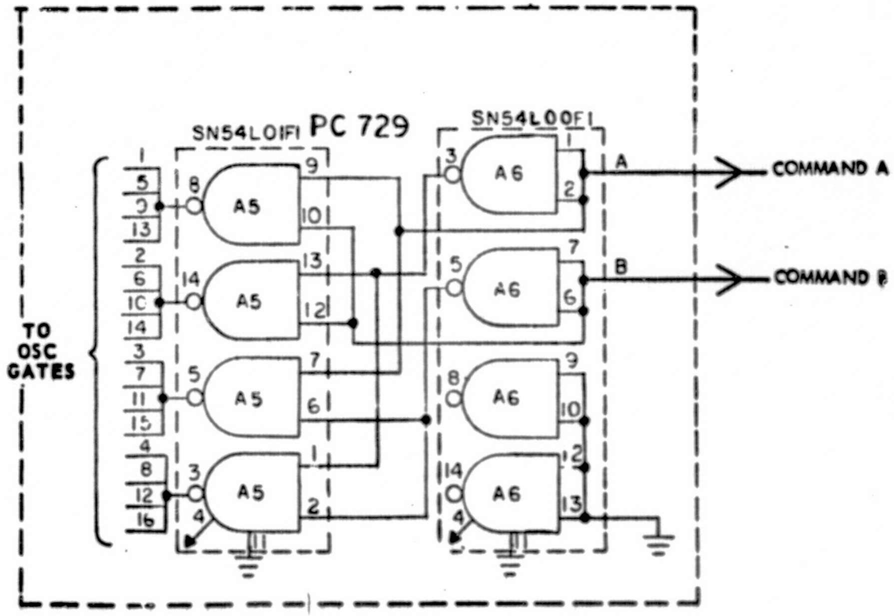


Figure 3-24. Schematic Diagram, Oscillator Switch (PC 729)

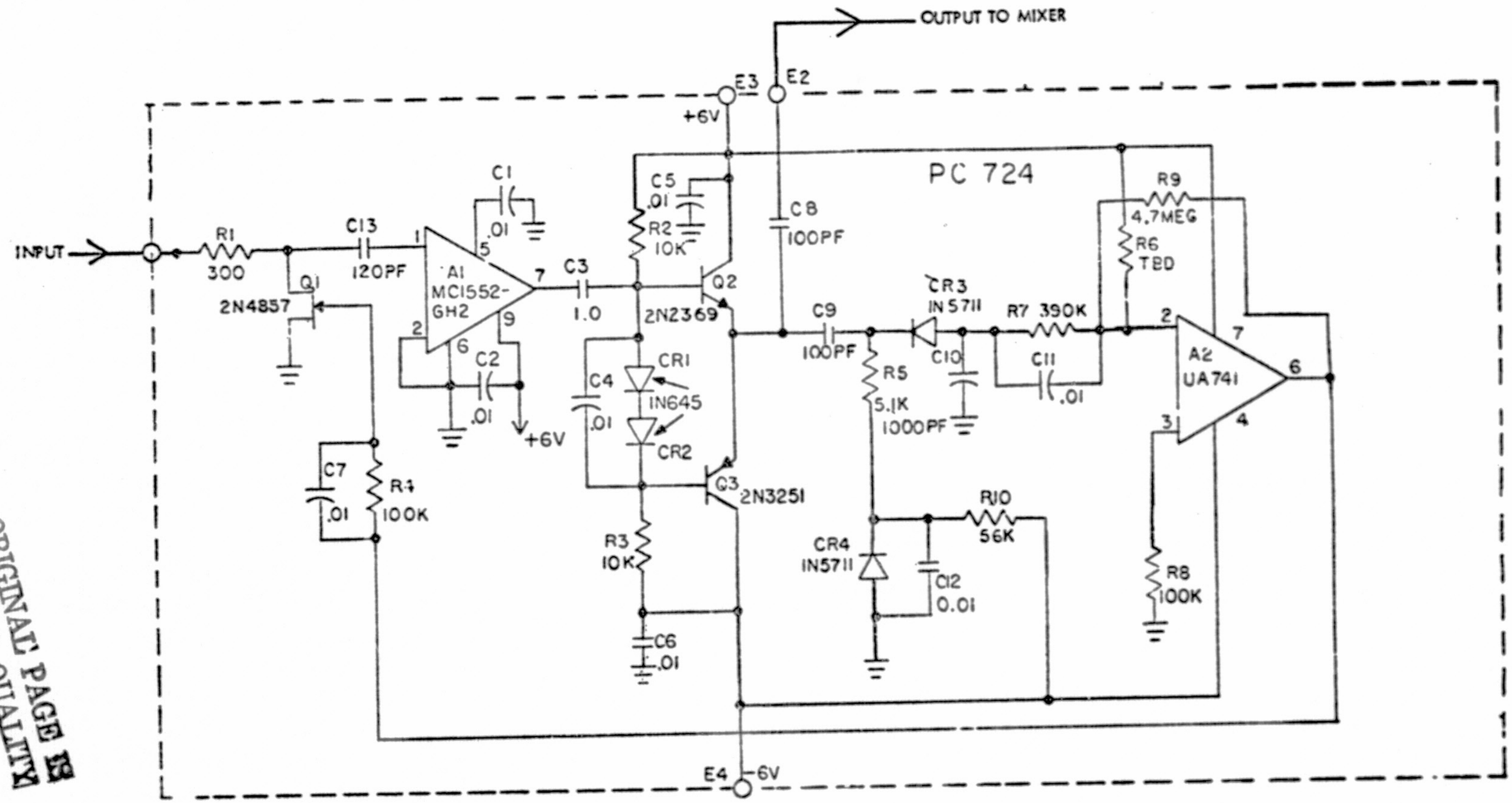


Figure 3-25. Schematic Diagram, A.G.C. Amplifier (PC 724)

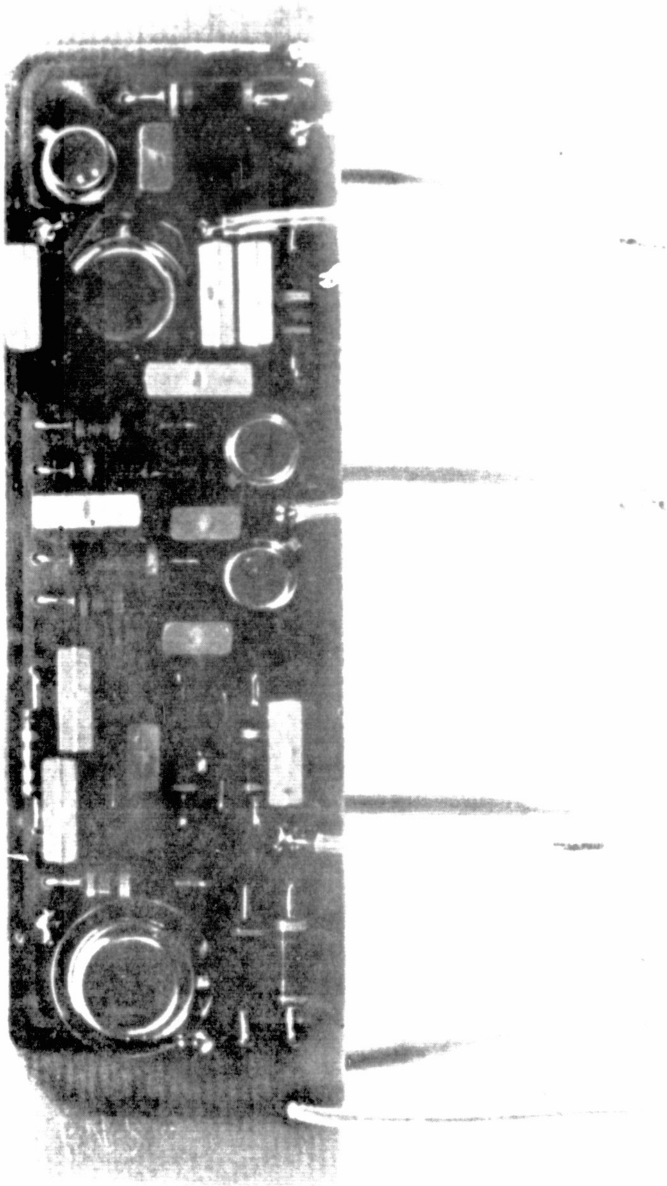


Figure 3-26. Component Location A.G.C. Amplifier (PC 724)

variable resistor to control the AGC gain. The unit is set up to give an output of 1 milliwatt by selecting R_6 to give the proper output.

3.2.10 Noise Source Circuit Description. The noise source is used in the system to provide a calibration signal to the input of the radiometer. The output is essentially flat in frequency from 26.5 kHz to 3 MHz and beyond. The circuit is shown in figure 3-27. Component arrangement is shown in figure 3-28.

The noise diode CR_1 provides the broad band noise when reverse biased by the + and -6 VDC supply. The output frequency response of the diode is shaped by an RC filter, R_{48-52} and C_{18-21}.

Amplification is provided by A_1. The signal is attenuated by R_{10} and Q_5, further amplified by Q_6, Q_7, and Q_8, and attenuated again by R_{25} and Q_9.

The output is connected to a transformer T_1 and coupled to each preamp 180° out of phase as required.

The levels of noise output are chosen so that the initial output with both attenuators energized will fall at the top of range 3. By turning A "off" the level decreases to the bottom of range 3. By turning B "off" the level should be in the middle of range 2. By turning off both A and B the level decreases to the middle of range 1. These levels are approximate and are given to provide fixed calibration points to each range and each channel.

3.2.11 Switching Cicuit Description. Switching is provided for +12 volt power and ±6 volt power to all circuits. In addition, all input commands are buffered and used to operate the radiometer. The switching circuits are contained on PC boards 725 and 723.

All command inputs are buffered by balanced FET inputs as shown in figure 3-29 (component arrangement is shown in figure 3-30). All input amplifiers are the same as the noise level amplifier.

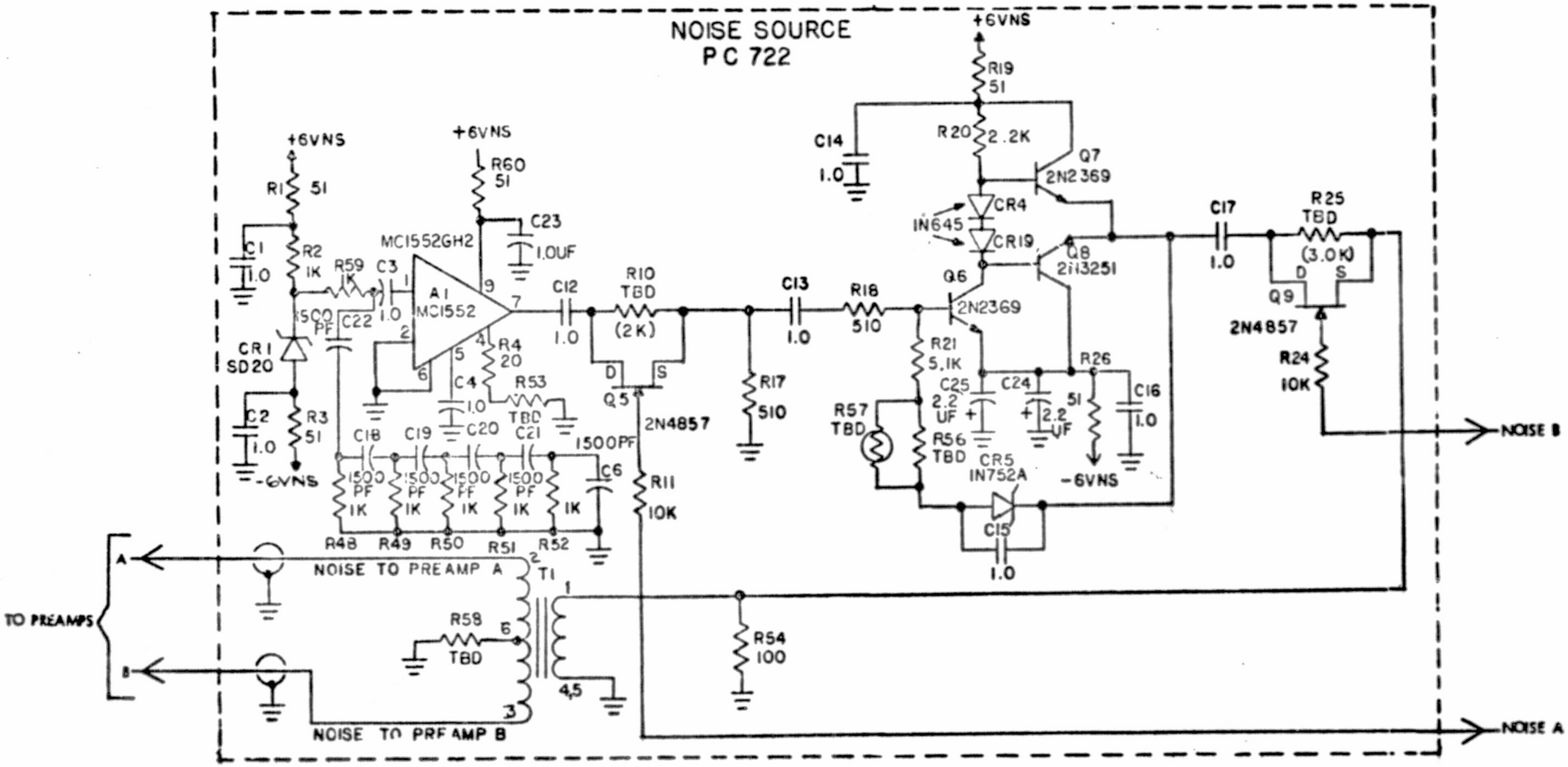


Figure 3-27. Schematic Diagram, Noise Source (PC 722)

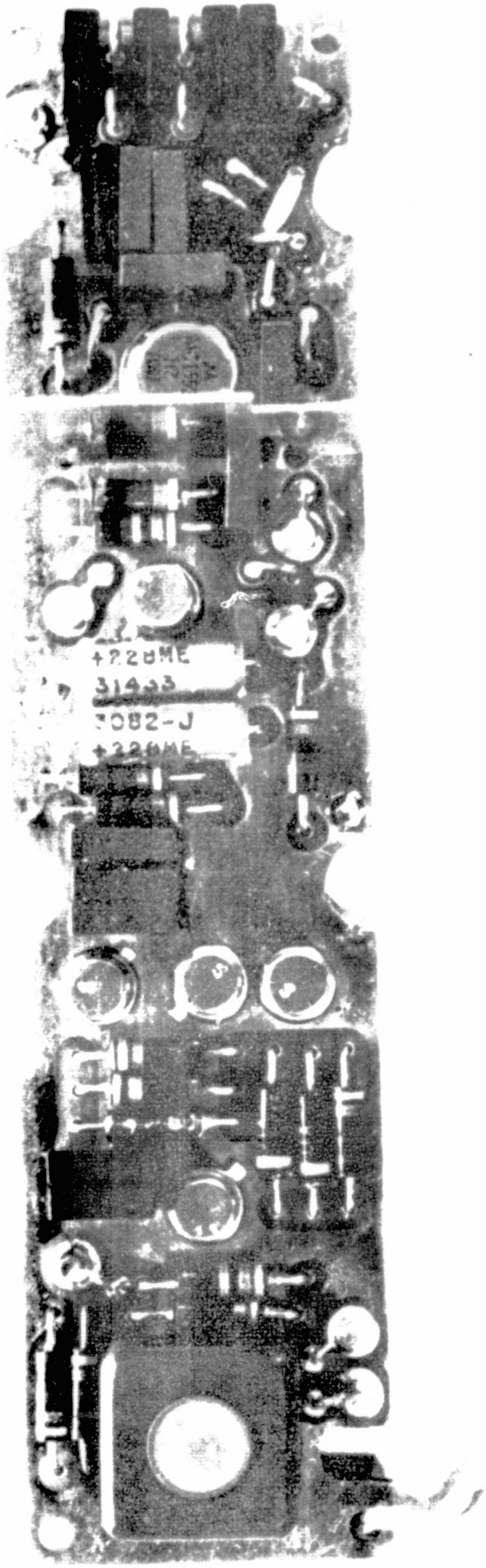


Figure 3-28. Component Location, Noise Source (PC 722)

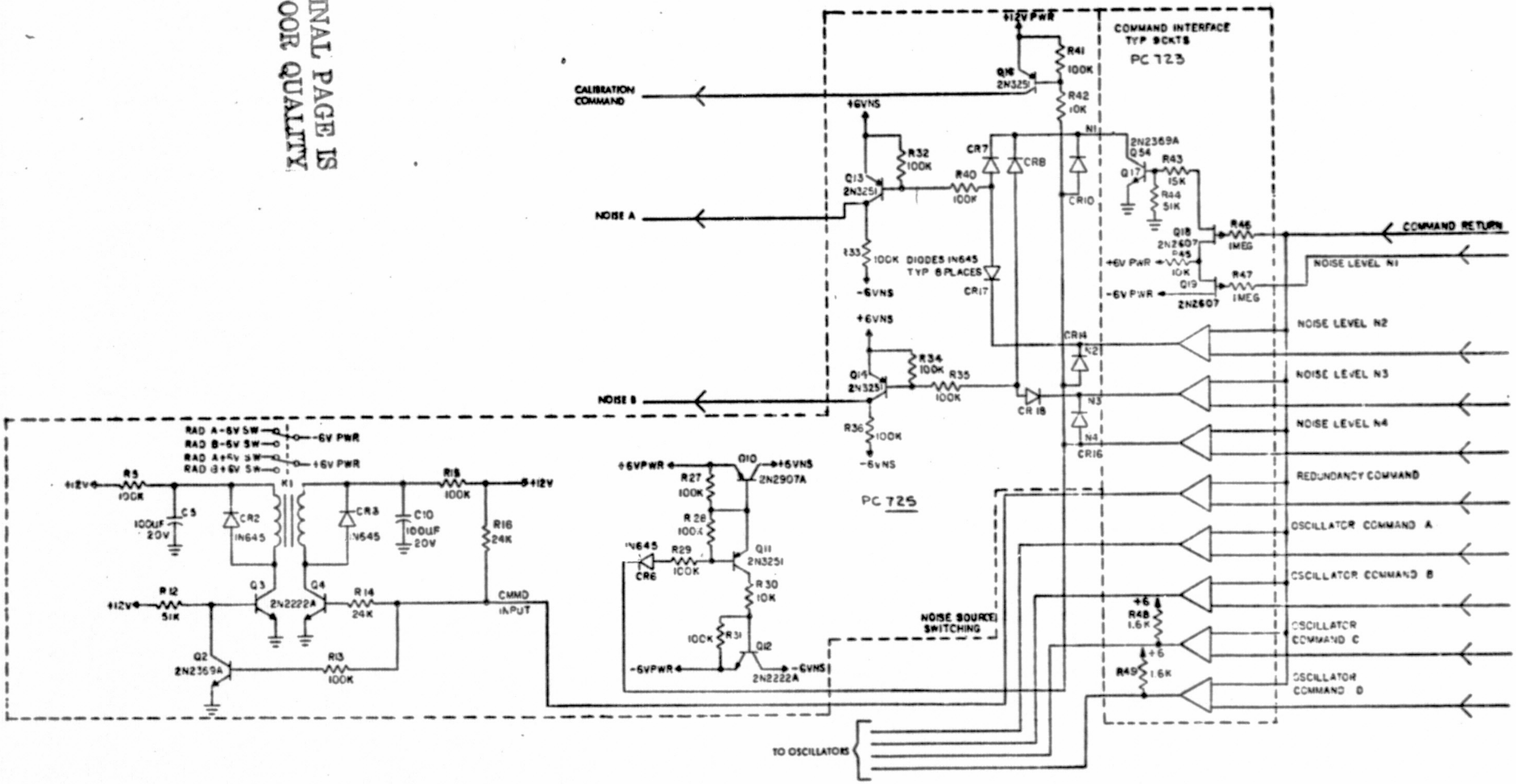


Figure 3-29. Schematic Diagram, Switching Circuit (PC 723 and PC 725)

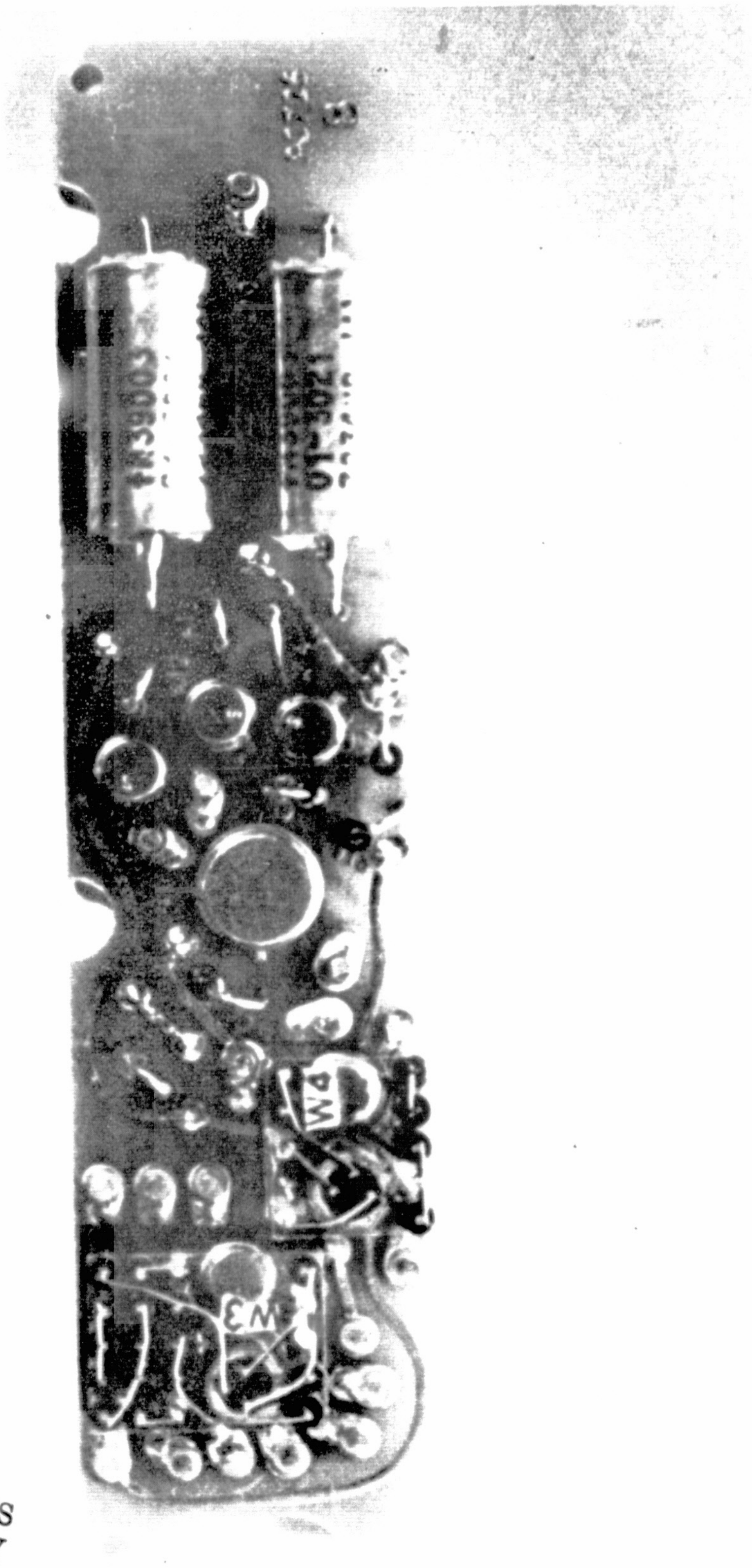


Figure 3-30. Component Location, Switching Circuit
(PC 723 and PC 725)

Noise source switching is accomplished by the four inputs N_1, N_2, N_3, and N_4 and the logic action of diodes CR_7, 8, 10, 14, 16, 17, and 18. The two outputs A and B are used to provide the required outputs.

The redundancy command is used to switch from radiometer B to A and from A to B. When the radiometer is first turned "on" and no redundancy command is applied, Q_3 will provide power to radiometer B through Relay K_1. When a command is received, Q3 will release and Q4 will conduct, causing power to be applied to radiometer A. The unit can be switched from A to B or B to A as required. If power is applied initially to A, the K_1 relay may jam. If both Q3 and Q_4 come on at the same time, the K_1 relay will not close in either position. To alleviate this condition, one must operate the command input to B. In this position the circuit will stabilize with Q_3 "on" and Q_4 "off". The time constants of C_5, R_5, C_{10}, and R_{15} are 10 seconds. To ensure that the circuits have stabilized, one must keep the command B circuit energized for at least 20 seconds, then one may switch from radiometer to radiometer without fear of malfunction.

The oscillator commands A, B, C, and D are buffered and connected to the oscillator switching as previously described.

3.2.12 Intra-System Connections. To facilitate understanding and analysis, a foldout figure 3-36 (figures 3-37 and 3-38 show two views, A and B, of an assembled radiometer) is provided at the end of this report which shows how all circuits are connected within the radiometer.

3.3 OPERATING INSTRUCTIONS FOR HELIOS GROUND SUPPORT EQUIPMENT

The operating instructions prepared for use with the GSE are a part of this section. These instructions describe the equipment and its operation. Two photographs are included: The front panel (operating position) is shown in figure 3-31 and the inside of the unit is shown in figure 3-32.

3.3.1 Ground Support Equipment.

The Helios Ground Support Equipment provides all power, signals and commands necessary to operate the dual swept radiometer in all modes of operation. It is capable of being externally controlled by the DPU and monitored by computer.

3.3.2 Functional Description.

3.3.2.1 Radio Frequency Section

3.3.2.1.1 Wide Band Mode.

In the wide band mode a high-level, wide band noise signal is produced in the noise source module. This signal is coupled through an attenuator to the mode switch.

3.3.2.1.2 Narrow Band Mode.

In the narrow band mode, the noise signal from the noise source module is coupled through a resistive divider to a bandpass filter with a center frequency of 8.0 MHz and a bandpass of 40 kHz. The output of this filter is injected into the RF port of a mixer where it is heterodyned with an L.O. signal brought to the mixer from an external source through a resistive divider. The output of the mixer is fed to an amplifier located in the noise source module. This amplifier signal is then coupled to the mode switch.

3.3.2.1.3 Sine Wave Mode.

In the sine wave mode, an external signal is brought through an attenuator to the mode switch.

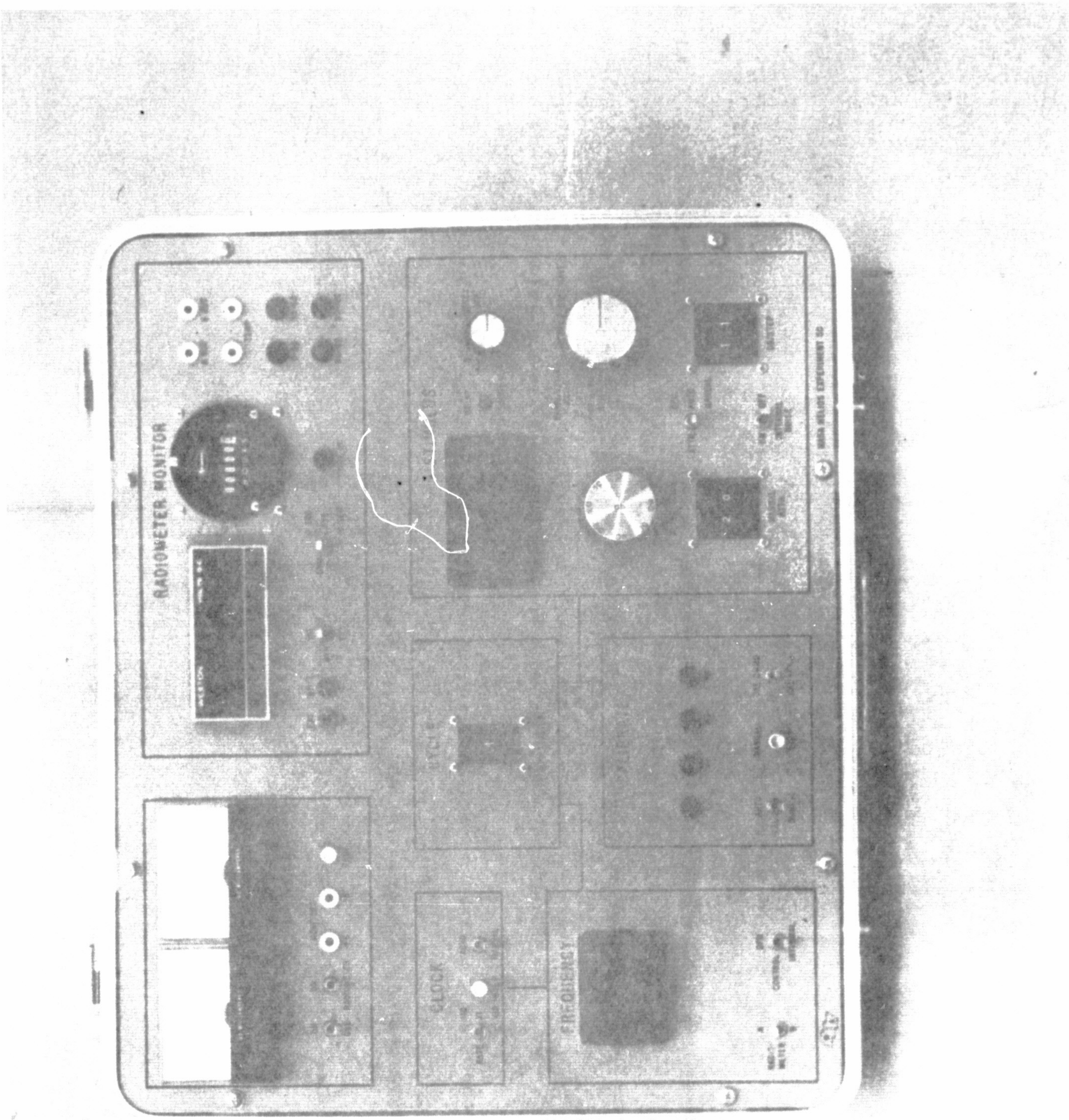


Figure 3-31. Ground Support Equipment, Front Panel View

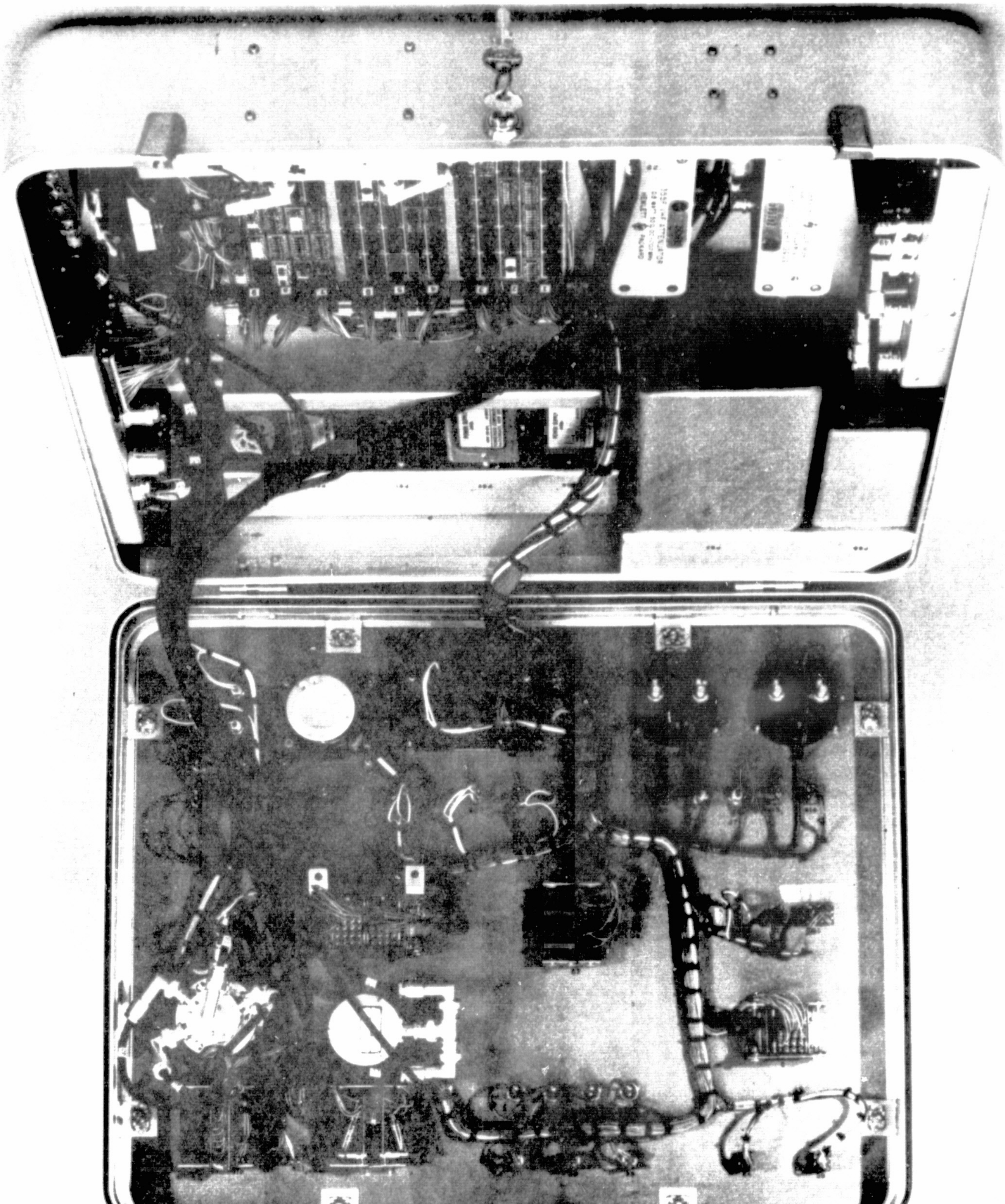


Figure 3-32. Ground Support Equipment
Interior View

3.3.2.1.4 External Mode. In the external mode, an external signal is brought directly to the mode switch.

3.3.3 Power Section. The power section monitors the currents and voltages that power the radiometer. The GSE power "on" switch turns power on to the GSE to allow warm-up of the noise source. The radiometer switch controls power to the radiometer. The $\pm$ 6 volt lines can be monitored for voltage with the DVM on external with a patch cord. The reset push-button resets all the internal automatic timing circuitry to the start of the cycle.

3.3.4 Clock Section. The clock section controls the timing of the radiometer. Three different clock rates are provided for selection of the optimum rate for the test to be performed. In the normal mode the radiometer will step one channel each time the manual step switch is depressed.

3.3.5 Frequency Section. The frequency section controls and displays the internal frequency of operation in the radiometer. The CHANNEL monitor decodes the four-line command going to the radiometer and displays the channel number in operation.

The radiometer A/B switch commands the redundancy switching circuit in the radiometer to turn on the respective radiometers.

The control DPU/INTERNAL switch selects the source of control for the radiometers oscillators. On INTERNAL, the oscillators are stepped with the clock. On DPU, four control lines from an external source directly control the channel selection.

3.3.6 Cycle Selection Section. The CYCLE/STEP switch controls the number of complete oscillator cycles (16 CHANNELS/CYCLE) before the attenuation changes.

3.3.7 Calibration Section. The CALIBRATE block produces the calibrate commands to initiate the calibration cycle of the radiometer using its internal noise source.

To initiate a calibrate command, the switch is depressed and released. With the calibration switch in the AUTO position, the GSE unit will cycle through all sixteen channels at each of the four noise levels and then terminate. By throwing the CAL switch to MANUAL, the noise source can be stepped manually with the MANUAL STEP.

Throwing the CAL HOLD/CAL CMMD switch to CAL HOLD will hold the radiometer in calibrate until the switch is released to the center position at which time the cycle will then finish the normal sequence and terminate.

Four lamps indicate the particular command being sent to the radiometer; these lamps illuminate only during a calibration cycle.

3.3.8 Stimulus Control Section. The STIMULUS controls the internal and external signal (noise) sources and levels used to stimulate the radiometer. The source levels can be controlled either manually or automatically.

The STIMULUS selector switch selects the desired source. The WIDEBAND NOISE is a direct output from the internal noise source. The NARROW BAND NOISE is a shaped signal 40 kHz wide and centered around the channel in use. The SINE WAVE is a sine wave tuned to the channel in use. The EXTERNAL position allows the use of any other desired generator.

The selected source is routed through the two attenuators. The automatic attenuator has a range of 129 db in 1 db steps and the MANUAL ATTENUATOR has a 70 db range in 10 db steps. The automatic attenuator can be controlled manually by use of thumbwheel switches. The ATTN SWITCH selects the desired mode of attenuation.

In the AUTO position, the attenuator steps every time the channels complete a complete cycle (16 positions). The number of db/attenuator steps is set with the DB/STEP thumbwheel switch.

The ATTENUATION, DB indicator always shows the setting of the auto attenuator independent of the operating mode.

The network selector selects the desired network to condition the signal as it enters the preamp. A lamp indicates that the relays in the network are drawing power.

3.3.9 Radiometer Monitor Section. This section monitors the outputs of the radiometer and records the total experiment operating time. The DVM, when ON INTERNAL, monitors the output of the commanded radiometer (A or B). On EXT, any DC voltage can be monitored with the use of test leads to the EXT IN jacks. The DVM TC switch filters the input signal with an RC time constant.

The output of radiometers A and B are available for connection to external equipment. The TEMP monitor provides a connection to the thermister in the radiometer.

Four lamps indicate the range in which the radiometer is currently operating. The elapsed time meter (ETM) records the operating time of the radiometer. The meter is "on" when the TIMER ON lamp is illuminated. The ETM will come "on" only when the radiometer is connected and drawing power. Thus, if the radiometer power switch is "on" and the radiometer is not hooked up the ETM will not run.

TABLE 3-2

GROUND SUPPORT EQUIPMENT CONTROLS

Control	Function
Power	
RADIOMETER - ON	Applies power to the radiometer when the GSE switch is "on".
GSE - ON	Turns power "on" for the GSE and enables the radiometer "on" switch.
RESET	Resets the GSE to the beginning of all automatic cycles (CHANNEL SELECT, CALIBRATE, AND ATTENUATOR).
Clock	
RATE	Selects GSE clock frequency for sequences.
STEP	Manually steps channels one at a time.
AUTO/MANUAL	Selects method of stepping channels.
Frequency	
CHANNEL	Shows channel number selected.
RADIOMETER	Selects radiometer to be powered.
CONTROL	Selects control method for channel stepping.

Control	Function
Cycle	
CYCLES/STEP	Selects the number of complete channel cycles before attenuator or noise calibration steps.
Calibrate	
N1-N4	Shows the calibrate command that is being sent to the radiometer.
CAL	Selects either automatic or manual stepping of noise commands.
CAL CMMD/CAL HOLD	Generates a calibration command or holds radiometer in calibration.
Stimulus	
ATTENUATION, DB	Shows setting of automatic attenuation.
ADDITIONAL ATTENUATION	Selects attenuation additional to auto attenuation.
MANUAL ATTENUATION	Selects attenuation in manual mode by use of thumbwheel switches.
INTERNAL NOISE	Turns GSE noise source "on" or "off."
ATTN	Selects the method of control for the programmable attenuator.
DB/STEP	Selects db step size in the automatic mode.

Control	Function
Selector	Selects the stimulus source.
Relay Selector	Selects the network in calibration cans.
RELAY CURRENT	Indicates power being drawn by relays in calibration assembly.
Radiometer Monitor	
DVM	Supplies digital readout of DC voltages on radiometer outputs.
EXT IN	Inputs of DVM.
DVM INT/EXT	Selects internal or external connection to DVM.
DVM TC	Selects time constant of input filter on DVM.
TIMER	Elapsed time meter for radiometer running time.
TIMER ON	Indicates when the timer is running.
A OUT, B OUT	Outputs of radiometer.
Temperature	Radiometer thermister connection.
R_1, R_2, R_3	Range of radiometer automatic gain circuit.

3.4 OPERATION

Operating FREQUENCY Determination

Step

1. Set up test equipment as shown in Figure 3-33.
2. Set signal generator output to 1 V rms.

PLACE GSE CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

CLOCK SECTION

3. RATE to X10
4. AUTO/MANUAL to MANUAL

FREQUENCY SECTION

5. RADIOMETER to A
6. CONTROL to INTERNAL

CYCLE SELECTION SECTION

7. Set to one

STIMULUS CONTROL SECTION

8. INTERNAL NOISE to OFF
9. INPUT SELECTOR to EXTERNAL
10. MANUAL ATTN to 60 db
11. ATTN to MANUAL
12. ADDITIONAL ATTENUATION to 0

RADIOMETER MONITOR SECTION

13. DVM to INT
14. DVM TC to 0

Step

15. Turn radiometer power on
16. Verify CHANNEL 1 ON
17. Verify attenuator at 60 db
18. Adjust signal generator to frequency 1
19. Adjust frequency for a maximum reading on DVM
20. Record frequency and DVM level
21. Decrease signal generator amplitude by 3 db
22. Record DVM level
23. Return signal generator to original amplitude, as in Step 19.
24. Locate frequencies above and below original frequency which show the same DVM level as in Step 21 - Record frequencies
25. Add frequencies and divide by 2. Record on data sheet
26. Depress step button in clock
27. Repeat steps 16 through 26 for frequencies 2-16
28. Repeat steps 16 through 27 for radiometer B

3.4.1. Signal Response - WIDE BAND NOISE

Step

1. Set-up test equipment as shown in Figure 3-34

PLACE GSE CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

CLOCK SECTION

2. RATE to X10
3. AUTO/MANUAL switch to MANUAL

FREQUENCY SECTION

Step

4. RADIOMETER to A
5. CONTROL to INTERNAL

CYCLE SELECTION SECTION

6. CYCLES/STEP to 1

STIMULUS CONTROL SECTION

7. ADDITIONAL ATTENUATION to 0
8. Selector switch to WIDEBAND NOISE
9. ATTN switch to AUTO
10. INTERNAL NOISE to ON
11. DB/STEP to 03

RADIOMETER MONITOR SECTION

12. DVM to INT
13. DVM TC to 0
14. Turn RADIOMETER power ON
15. Verify TIMER ON lamp illuminated
16. Record reading on elapsed time meter
17. Depress RESET
18. Record reading on DVM
19. Depress STEP switch and verify GSE channel indicator goes to next channel
20. Record reading on DVM
21. Continue steps 19 and 20 for all 16 channels
22. Verify ATTENUATION, DB changes 3 db

Step

23. Repeat steps 19 through 22 until attenuator resets to original reading (129 db)

24. Repeat steps 17 through 23 for RADIOMETER B

25. If no more tests at this time, turn off radiometer power and record elapsed time meter reading

3.4.2. Signal Response - NARROW BAND NOISE

Step

1. Set-up test equipment as shown in Figure 3-35

PLACE GSE CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

CLOCK SECTION

2. RATE to X10

3. AUTO/MANUAL switch to MANUAL

FREQUENCY SECTION

4. RADIOMETER to A

5. CONTROL to INTERNAL

CYCLE SELECTION SECTION

6. CYCLES/STEP to 1

STIMULUS CONTROL SECTION

7. ADDITIONAL ATTENUATION to 0

8. Selector switch to NARROW BAND NOISE

9. ATTN switch to AUTO

10. INTERNAL NOISE to ON

11. DB/STEP to 03

RADIOMETER MONITOR

Step

12. DVM to INT

13. DVT TC to 0

PLACE SYNTHESIZER CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

14. Set 10 MHz, 1 MHz, 100 kHz, 10 kHz, 1 kHz, and 100 Hz decades to R

15. Set 10 Hz and 1 Hz decade to 0

16. Push CAD OFF

17. Set output volts to 2 V

18. Turn RADIOMETER power ON

19. Verify TIMER ON lamp illuminated

20. Record reading on elapsed time meter

21. Depress RESET

22. Record reading on DVM

23. Depress STEP switch and verify GSE channel indicator goes to next channel

24. Record reading on DVM

25. Continue steps 23 and 24 for all 16 channels

26. Verify ATTENUATION, DB changes 3 db

27. Repeat steps 23 through 26 until attenuator resets to original reading (129 db)

28. Repeat steps 21 through 27 for RADIOMETER B

29. If no more tests at this time, turn "off" radiometer power and record elapsed time meter reading

3.4.3 **Signal Response - Sine Wave**

Step

1. Set-up test equipment as shown in Figure 3-35

PLACE GSE CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

CLOCK SECTION

2. RATE to X 10
3. AUTO/MANUAL switch to MANUAL

FREQUENCY SECTION

4. RADIOMETER to A
5. CONTROL to INTERNAL

CYCLE SELECTION SECTION

6. CYCLES/STEP to 1

STIMULUS CONTROL SECTION

7. ADDITIONAL ATTENUATION to 0
8. Selector switch to SINE WAVE
9. ATTN switch to AUTO
10. INTERNAL NOISE to ON
11. DB/STEP to 03

RADIOMETER MONITOR SECTION

12. DVM to INT
13. DVM TC to 0

PLACE SYNTHESIZER CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

14. Set 10 MHz, 1 MHz, 100 kHz, 10 kHz, 1 kHz, and
15. 100 Hz decades to R
16. Set 10 Hz and 1 Hz decade to 0

Step

17. Depress CAD OFF
18. Set output volts to 2V
19. Turn RADIOMETER power ON
20. Verify TIMER ON lamp illuminated
21. Record reading on elapsed time meter
22. Depress RESET
23. Record reading on DVM
24. Depress STEP switch and verify GSE channel indicator goes to next channel
25. Record reading on DVM
26. Continue steps 24 and 25 for all 16 channels
27. Verify ATTENUATION, DB changes 3 db
28. Repeat steps 24 through 27 until attenuator resets to original reading (129 db).
29. Repeat steps 22 through 28 for radiometer B
30. If no more tests at this time, turn "off" radiometer power and record elapsed time meter reading

3.4.4 Internal Noise Calibration

Step

1. Set-up test equipment as shown in Figure 3-34

PLACE GSE CONTROL SWITCHES IN THE POSITIONS INDICATED BELOW:

CLOCK SECTION

2. RATE to X 10
3. AUTO/MANUAL to MANUAL

Step

FREQUENCY SECTION

4. RADIOMETER to A

5. CONTROL to INTERNAL

CYCLE SELECTION SECTION

6. CYCLES/STEP to 1

CALIBRATE SECTION

7. CAL to AUTO

RADIOMETER MONITOR SECTION

8. DVM to INT

9. DVM TC to 0

10. Verify RADIOMETER power ON

11. Initiate CAL CMMD

12. Verify channel monitor on channel 1

13. Record DVM reading

14. Depress STEP switch and verify channel monitor steps to next channel

15. Repeat steps 13 and 14 for all channels

16. Verify calibrate noise lamp N4 extinguishes and N3 illuminates

17. Repeat steps 13 through 16 for all noise levels

18. Verify noise level lamps all extinguished at end of cycle

19. Repeat steps 11 through 18 for radiometer B

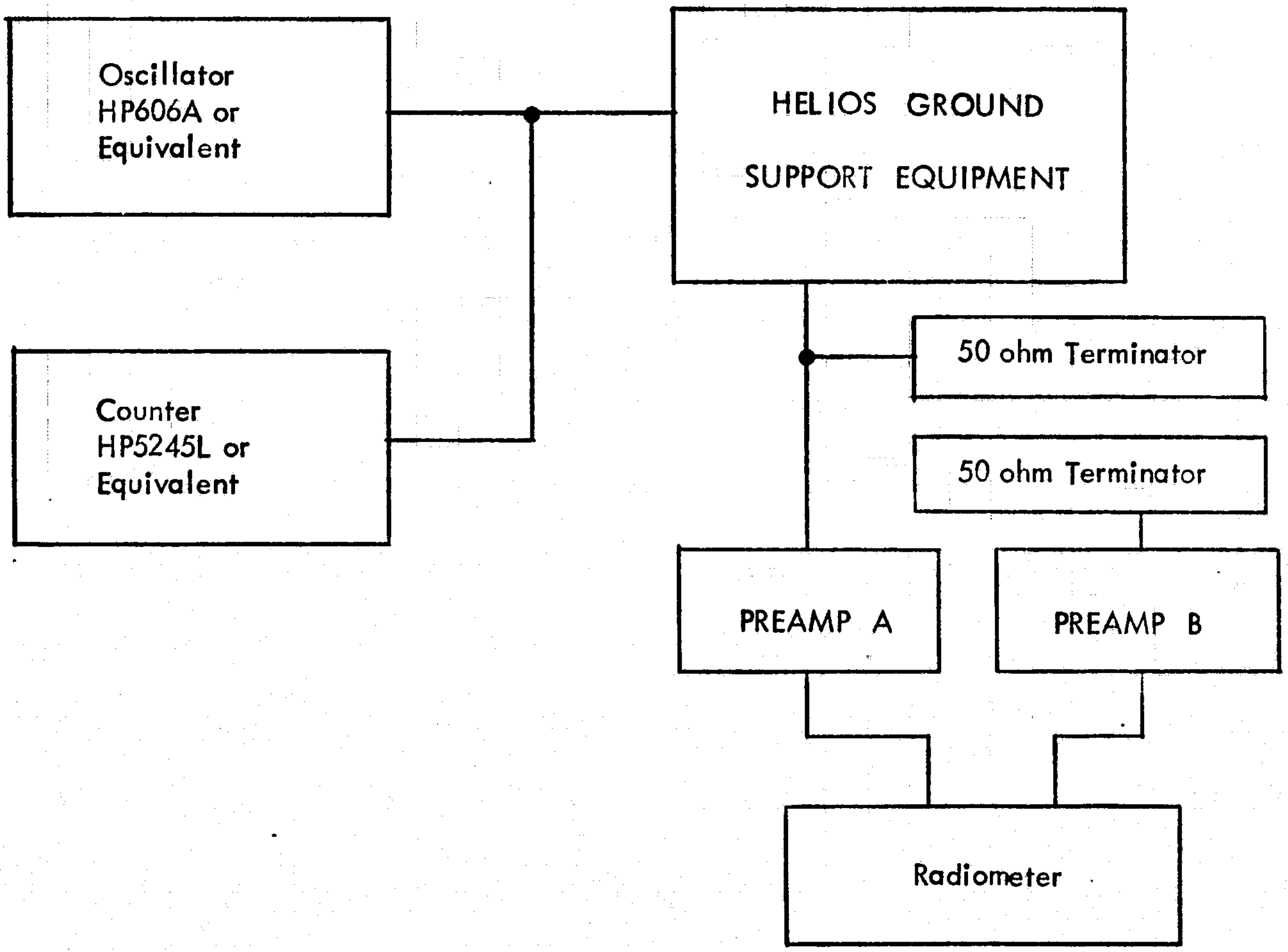


Figure 3-33. Test Equipment Set-Up, Operating Frequency Determination

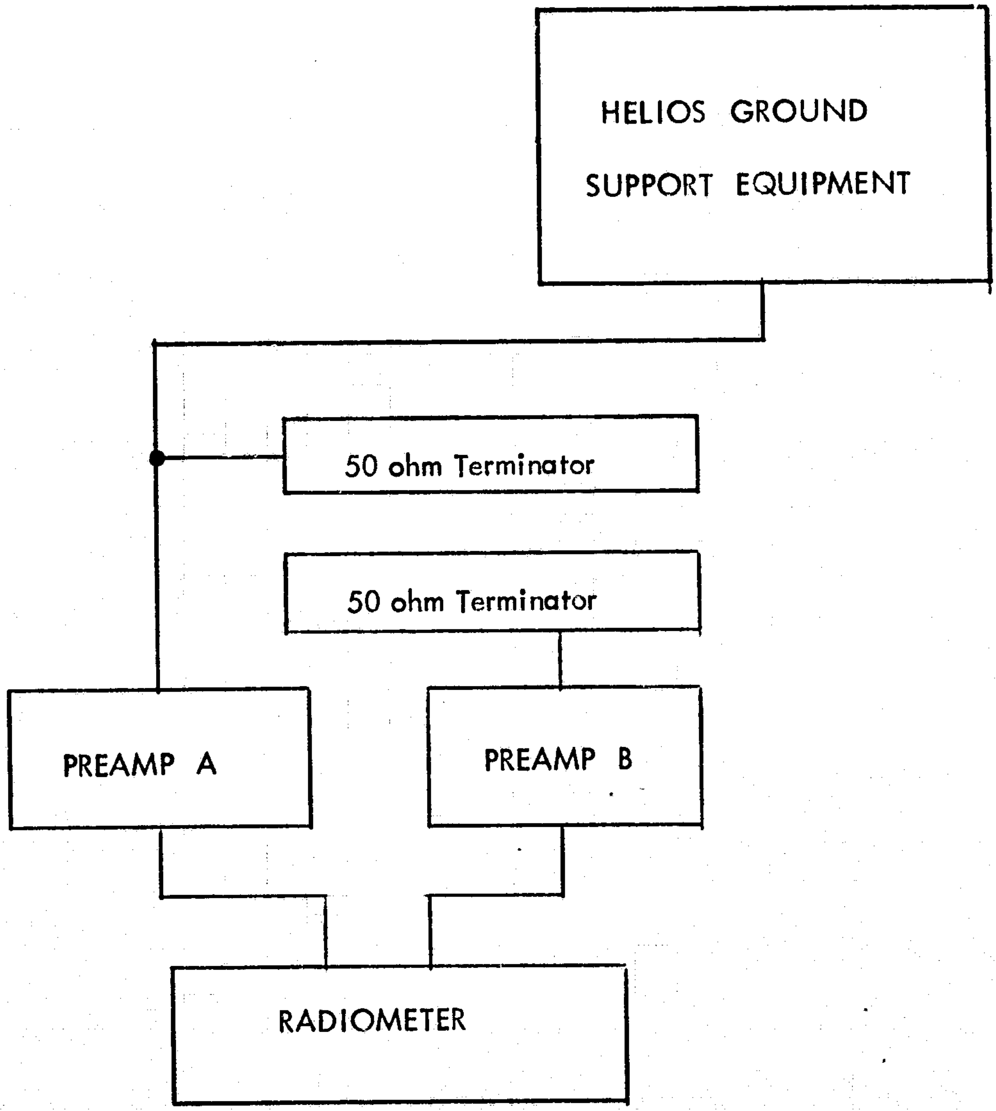


Figure 3-34. Test Equipment Set-Up, Signal Response - Wide Band Noise and Internal Noise Calibration

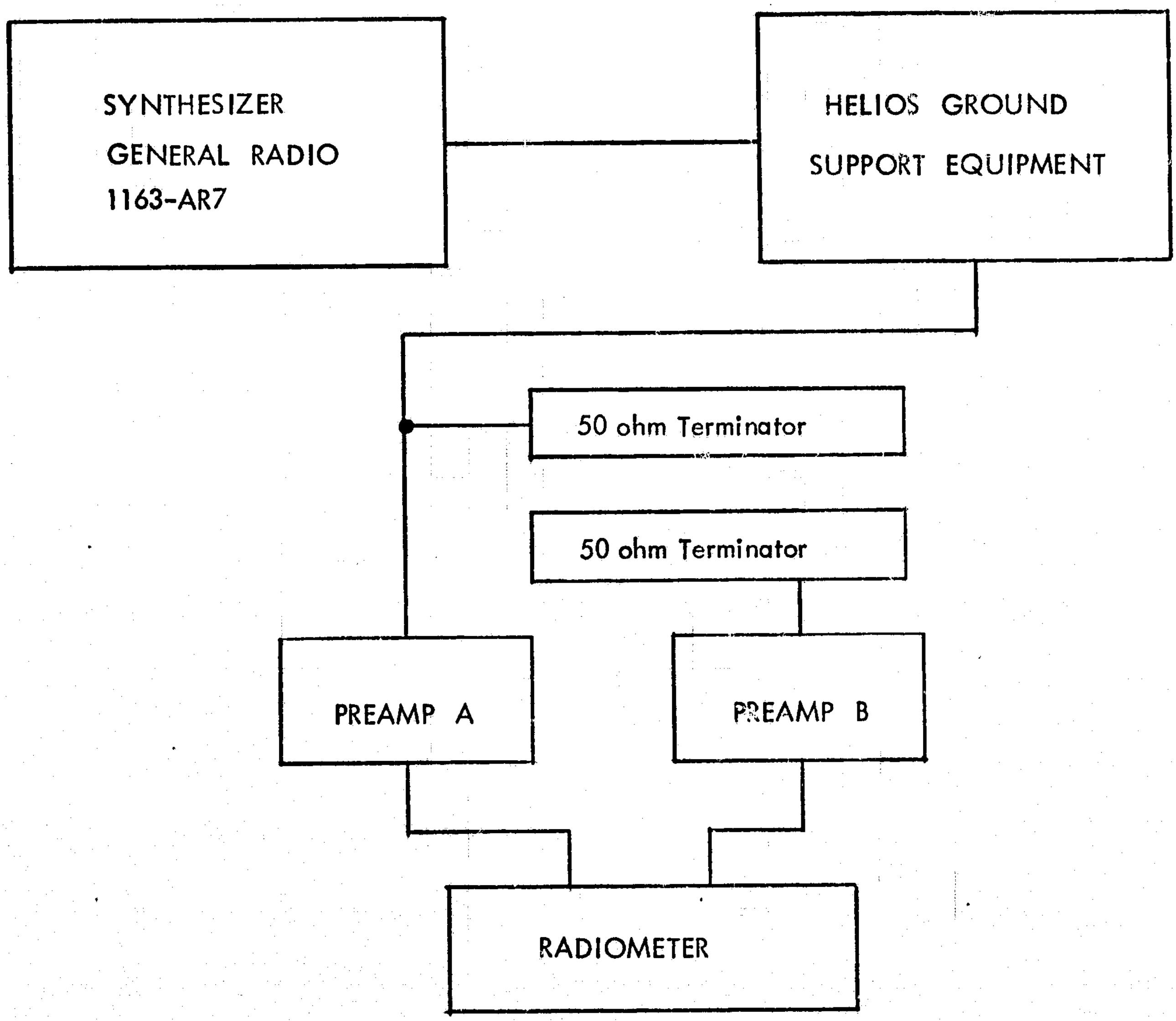
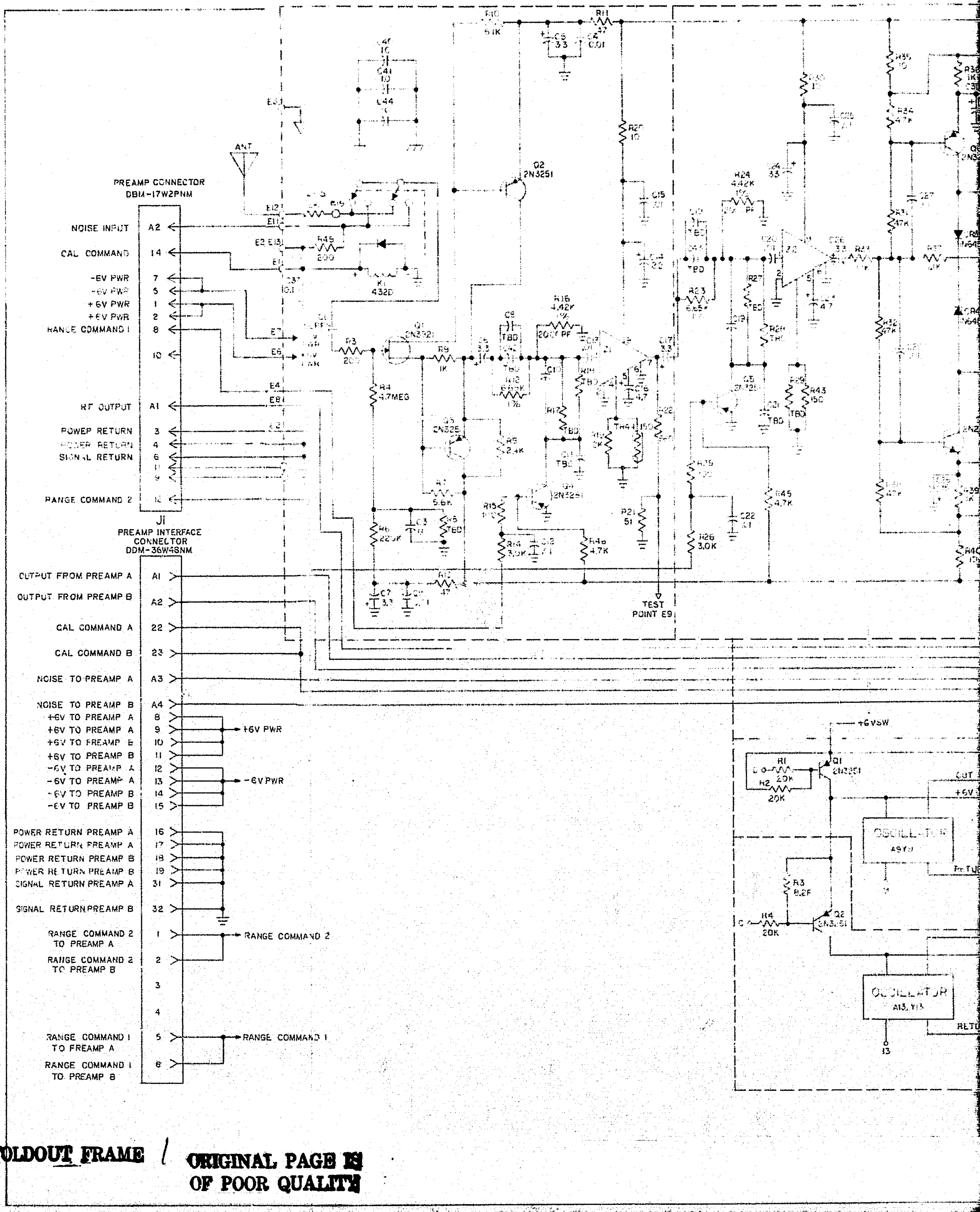


Figure 3-35. Test Equipment Set-Up, Signal Response - Narrow Band Noise and Signal Response - Sine Wave



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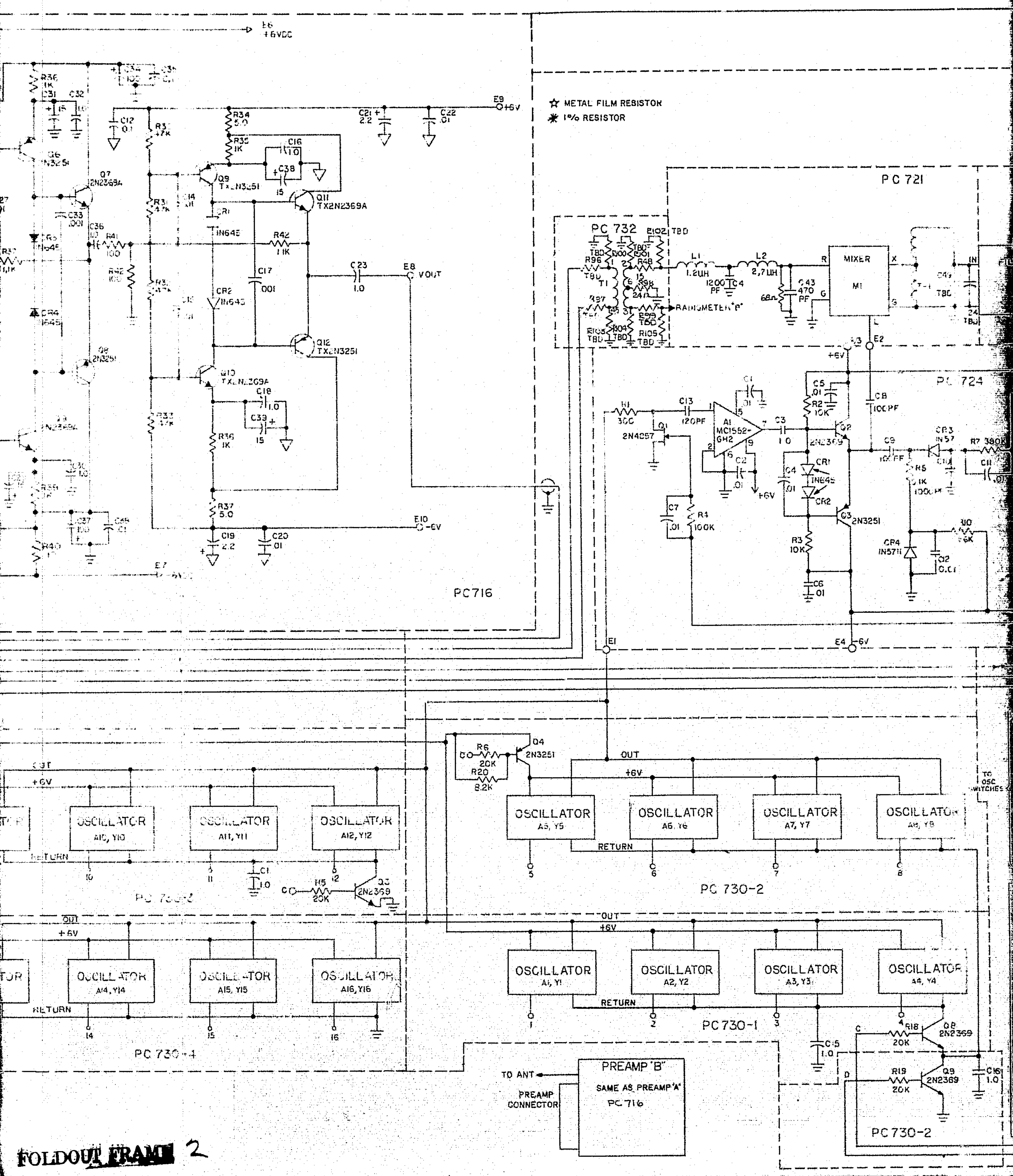
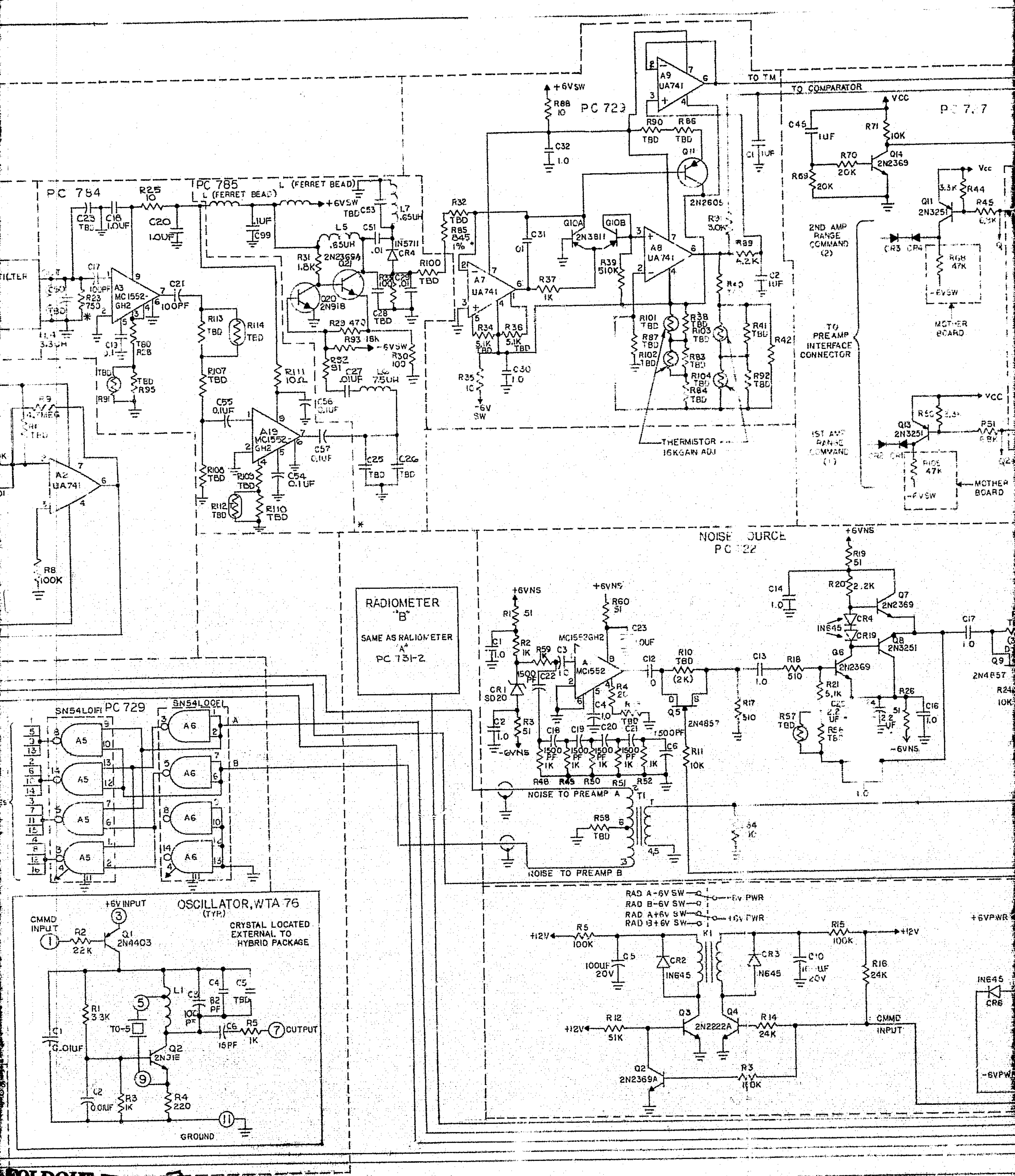
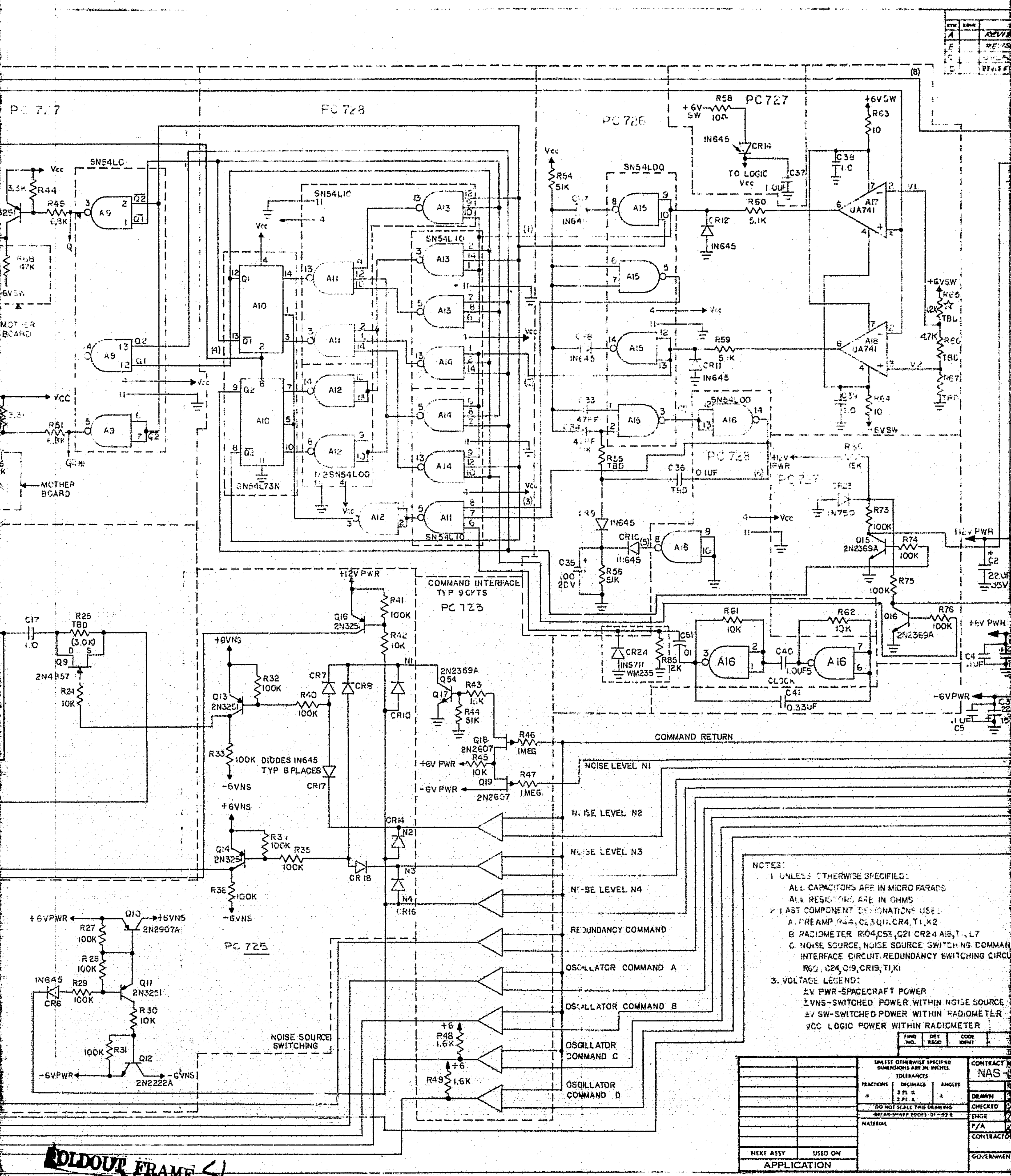


FOLDOUT FRAME 2



FOLDOUT FRAME 3



FOLDOUT FRAME 2

Figure 3-36. System Interconne

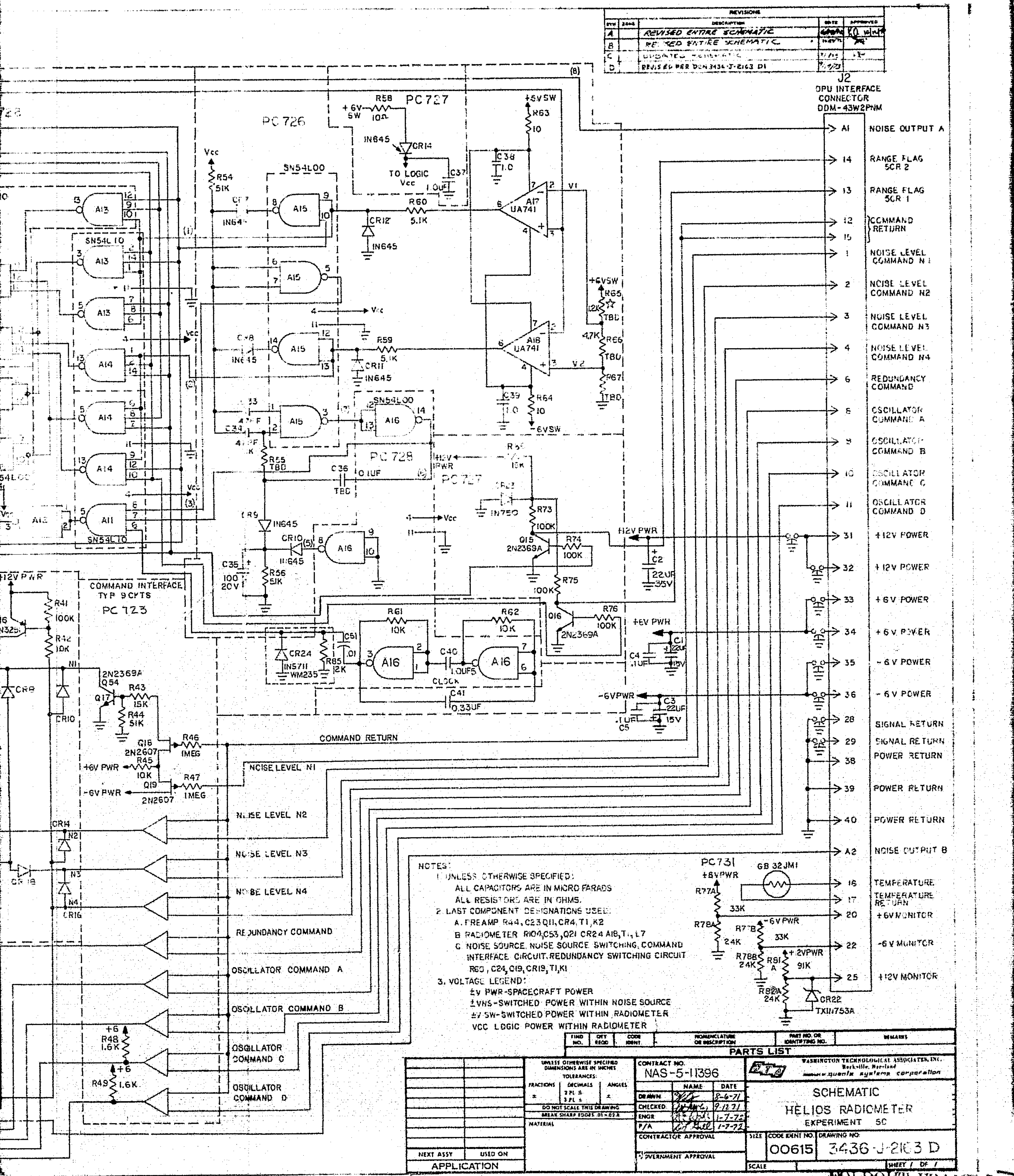


Figure 3-36. System Interconnecting Diagram, Radiometer

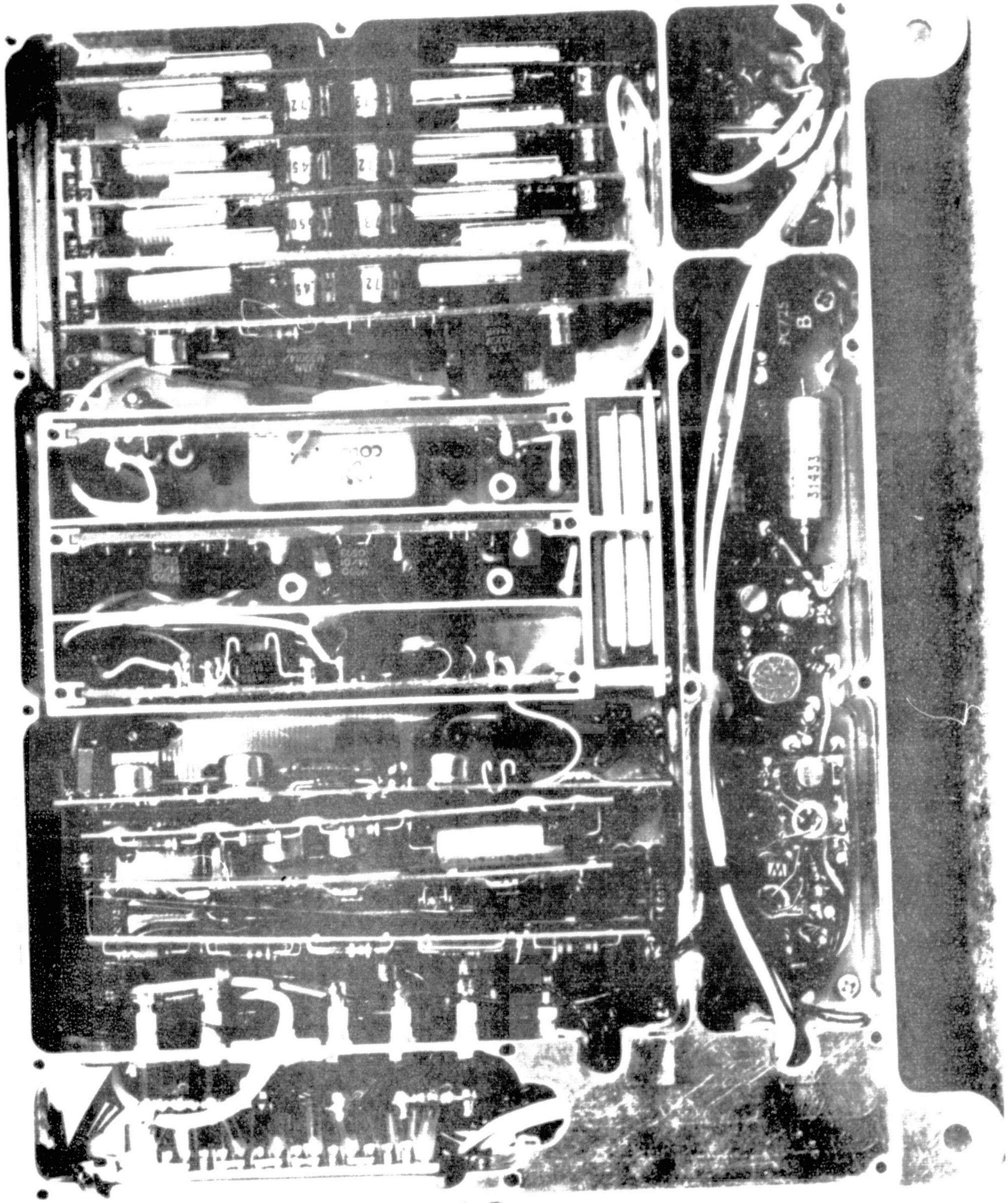


Figure 3-37. Assembled Radiometer View "A"

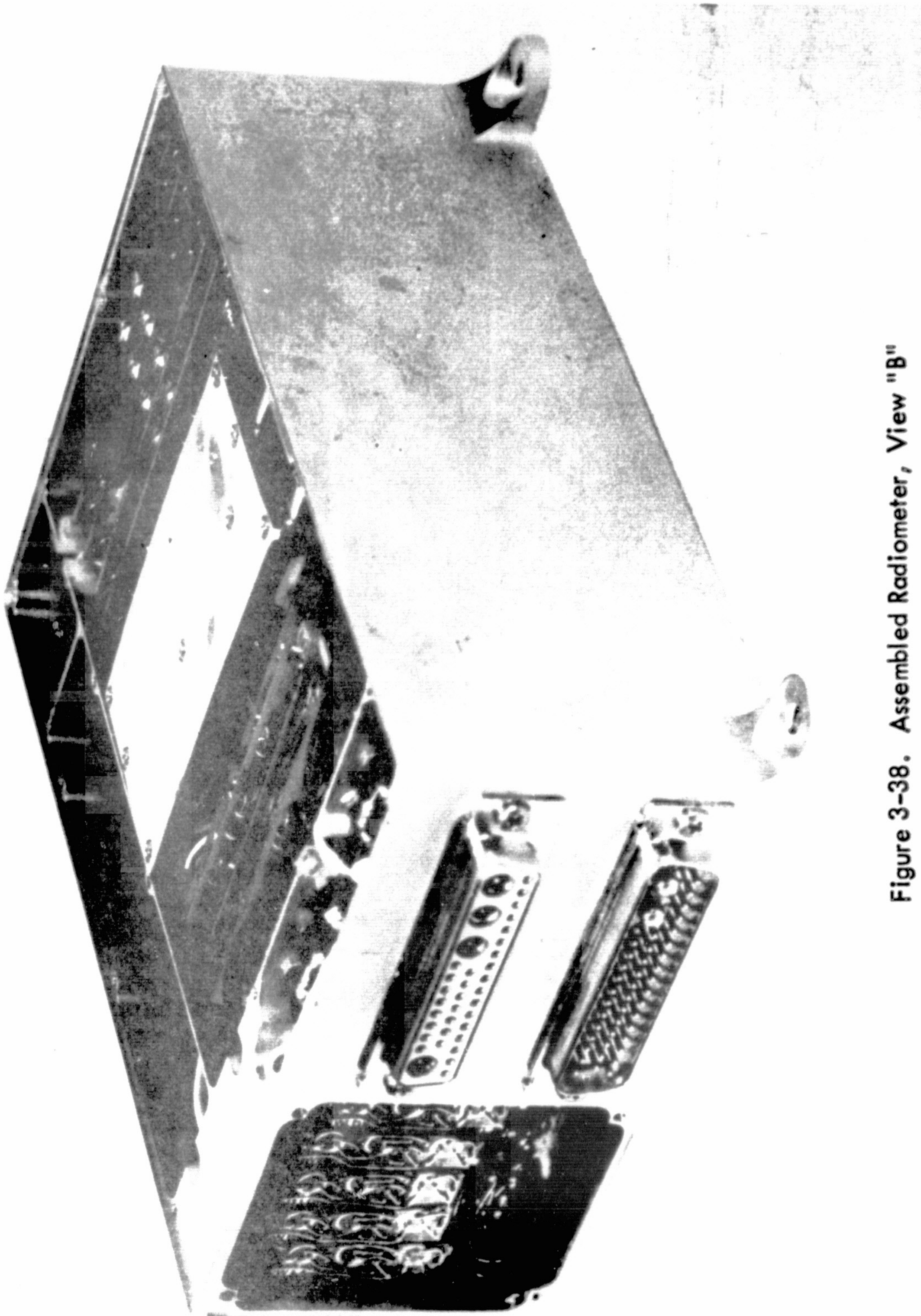


Figure 3-38. Assembled Radiometer, View "B"

SECTION 4
PARTS LIST

WTA
WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: HELIOS PREAMP RADIOMETER EXPERIMENT 5C PC716

PL 3436-F2002 — REV A

Symbols
T – TOTAL QUANTITY OR RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Sh
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			CKR05BX560KS	Capacitor, C1	MIL-C-39014/1
2	3			CYR41E5R9FPS	Capacitor, C2, C6, C32	MIL-C-39014/2
3	5			CKR06BX105KS	Capacitor, C3, C11, C16, C18, C23	MIL-C-39014/2
4	6			CKR06BX103KS	Capacitor, C14, C15, C20, C22, C27, C29	MIL-C-39014/2
5	4			CSR13G225KS	Capacitor, C19, C21, C26, C28	MIL-C-39003/1
6	4			CKR06BX473KS	Capacitor, C4, C9	MIL-C-39014/2
7	2			CKR05BX540KS	Capacitor, C30, C31	MIL-C-39014/1
8	9			CKR05BX104KS	Capacitor, C5, C7, C9, C10, C12, C13, C24, C25, C37	MIL-C-39014/1
9	1			CKR05BX102KS	Capacitor, C17	MIL-C-39014/1
10	4			CYR41E FPS	Capacitor, C33, C34, C35, C36	MIL-C-
11	2			P17(01)1S156R-K10	Capacitor, C38, C39	GSFC S311-P17(01)-1
12	4			RCR07G201JS	Resistor, R1, R8, R19, R45	MIL-R-39008/1
13	1			RCR07G475JS	Resistor, R2	MIL-R-39008/1
14	10			RCR07G103JS	Resistor, R5, R7, R11, R18, R20, R29, R9, R38, R39, R40	MIL-R-39008/1
15	1			RCR07G224JS	Resistor, R4	MIL-R-39008/1
16	1			RCR07G222JS	Resistor, R6	MIL-R-39008/1
17	2			RCR07G JS	Resistor, R43, R44	MIL-R-39008/1
18	5			RCR07G JS	Resistor, R3, R10, R12, R21, R22	MIL-R-39008/1
19	2			RCR07G912JS	Resistor, R12, R23	MIL-R-39008/1

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WTA

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: HELIOS PREAMP RADIOMETER EXPERIMENT 5C PC716

PL 3436F-2002

REV A

Symbols
T – TOTAL QUANTITY OR RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Sh Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
20	2			RCR07G112JS	Resistor, R29, R42	MIL-R-39008/1
21	2			RCR07G104JS	Resistor, R16, R26	MIL-R-39008/1
22	4			RCR07G102JS	Resistor, R17, R27, R35, R36	MIL-R-39008/1
23	4			RCR07G473JS	Resistor, R30, R31, R32, R33	MIL-R-39008/1

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.	Title	PL	REV
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852 *Subsidiary of Quanta Systems Corporation*	HELIOS PREAMP RADIOMETER EXPERIMENT 5C PC716	3436-F-2002	A

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
24	2			RCR07G050JS	Resistor, R34, R37	MIL-R-39008/1
25	2			RNR55C3012FS	Resistor, R14, R25	MIL-R-551 2/1
26	2			RNR55C9200FS	Resistor, R15, R24	MIL-R-55182/1
27	1			432-12	Relay (432-7166), K1	S-311-P-2(06)
28	2			TX1N645	Diode, CR1, CR2	MIL-S-19500/270C
29	1			TX2N3821	Transistor, (FET), Q1	MIL-S-18055/375A
30	5			TX2N3251A	Transistor, Q2, Q5, Q8, Q9, Q12	MIL-S-19500/323A
31	2			Tx2N2920	Transistor, (Dual), Q3, Q6	MIL-S-1 5 0/355A
32	2			TX2N4357	Transistor, (FET), Q4, Q7	MIL-S-1 500/317D
33	4			Tx2N2369A	Transistor, Q10, Q11, Q13, Q14	MIL-S-19500/317D

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Preamp Radiometer PC 716

E=Estimate

Schematic No. 3436-J-2163

Drawing No.& Parts List No. 3436-F-2002

Page 1 of 5

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp.°C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
C1	CKR05BX150KS	Capacitor	Mil-C-39014/1	.001	1%	70	F	PF		
C2	CYR41E5ROFPS	Capacitor	Mil-C-23269/9	.001	1%	70	PF	PF		
C6	"	"	"	.001	1%	70	PF	PF		
C32	"	"	"	.001	1%	70	PF	PF		
C3	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	12%	70	PF	F		
C11	"	"	"	.001	12%	70	F	F		
C16	"	"	"	.001	10%	70	F	F		
C18	"	"	"	.001	20%	70	PF	F		
C23	"	"	"	.001	20%	70	F	F		
C14	CKR06BX103KS	Capacitor	Mil-C-39014/2	.001	10%	70	F	F		
C15	"	"	"	.001	10%	70	F	F		
C20	"	"	"	.001	25%	70	PF	F		
C22	"	"	"	.001	25%	70	PF	F		
C27	"	"	"	.001	10%	70	PF	F		
C29	"	"	"	.001	25%	70	PF	F		
C19	CSR13G225KS	Capacitor	Mil-C-39003/1	.001	25%	70	PF	F		
C21	"	"	"	.001	25%	70	PF	F		
C26	"	"	"	.001	25%	70	PF	F		
C28	"	"	"	.001	25%	70	PF	F		
C 4	CKR06BX473KS	Capacitor	Mil-C-39014/2	.001	10%	70	F	F		
C 8	"	"	"	.001	10%	70	F	F		
C30	CKR05BX560KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	F		
C31	"	"	"	.001	10%	70	PF	F		

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title: Preamp Radiometer PC 716
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436- F-2002 Page 2 of 5

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
C5	CKR05BX104KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	F		
C7	CKR05BX104KS	"	"	.001	20%	70	PF	F		
C9	"	"	"	.001	20%	70	PF	F		
C10	"	"	"	.001	20%	70	PF	F		
C12	"	"	"	.001	30%	70	PF	F		
C13	"	"	"	.001	30%	70	PF	F		
C37	"	"	"	.001	25%	70	F	PF		
C24	"	"	"	.001	20%	70	PF	F		
C25	"	"	"	.001	20%	70	PF	F		
C17	CKR05BX102KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	PF		
C33	CKR05BX104KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	F		
C34	"	"	"	.001	5%	70	PF	F		
C35	"	"	"	.001	10%	70	PF	PF		
C36	"	"	"	.001	5%	70	PF	PF		
C38	P17(01)1S156R-K-10	Capacitor	GSFC S311-P-17-(01)-1	.001	10%	70	F	F		
C39	"	"	"	.001	20%	70	PF	F		
R1	RCR07G201JS	Resistor	Mil-R-39008/1	.001	2%	70	F	PF		
R8	"	"	"	.001	1%	70	F	PF		
R19	"	"	"	.001	1%	70	F	PF		
R45	"	"	"	.001	10%	70	PF	F		
R2	RCR07G475JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Preamp Radiometer PC 716
Schematic No. 3436-J-2163
Drawing No& Parts List No. 3436-F-2002 Page 3 of 5

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp.°C.	Effect of Failure Open	Short	Other	Remarks/Notes
R5	RCR07G103JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		
R7	"	"	"	.001	2%	70	F	F		
R11	"	"	"	.001	2%	70	PF	F		
R18	"	"	"	.001	5%	70	F	F		
R20	"	"	"	.001	5%	70	PF	F		
R28	"	"	"	.001	5%	70	F	F		
R9	"	"	"	.001	5%	70	F	F		
R38	"	"	"	.001	5%	70	F	F		
R39	"	"	"	.001	5%	70	F	F		
R40		"	"	.001	5%	70	F	F		
R4	RCR07G224JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		
R6	RCR07G222JS	Resistor	"	.001	25%	70	F	F		
R43	RCR07G JS	Resistor	Mil-R-39008/1	.001	1%	70	PF	PF		TBD
R44	"	"	"	.001	1%	70	PF	PF		TBD
R3	RCR07G JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		TBD
R10	"	"	"	.001	1%	70	F	NF		TBD
R12	"	"	"	.001	1%	70	F	NF		TBD
R21	"	"	"	.001	1%	70	F	PF		TBD
R22	"	"	"	.001	1%	70	F	PF		TBD
R13	RCR07G912JS	Resistor	"	.001	10%	70	F	F		
R23	"	"	"	.001	30%	70	F	F		
R29	RCR07G112JS	Resistor	Mil-R-39008/1	.001	5%	70	F	F		
R42	"	"	"	.001	10%	70	F	F		

C/2

WTA Job No. 3436-002
Contract NAS5-11395

Failure Mode and Effects Analysis

E=Estimate

Title: Preamp Radiometer PC 716
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-F-2002 Page 4 of 5

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
R16	RCR07G104JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		
R26	"	"	"	.001	1%	70	F	F		
R17	RCR07G102JS	Resistor	Mil-39008/1	.001	30%	70	F	F		
R27	"	"	"	.001	30%	70	F	F		
R35	"	"	"	.001	10%	70	F	F		
R36	"	"	"	.001	25%	70	F	F		
R30	RCR07G473JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		
R31	"	"	"	.001	10%	70	F	F		
R32	"	"	"	.001	10%	70	F	F		
R33	"	"	"	.001	5%	70	F	F		
R34	RCR07G050JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		
R37	"	"	"	.001		70	F	F		
R14	RNR55C3012S	Resistor	Mil-R-55182/1	.001	5%	70	F	F		
R25	"	"	"	.001	5%	70	F	F		
R15	RNR55C9200FS	Resistor	Mil-R-55182/1	.001	10%	70	PF	F		
R24	"	"	"	.001	10%	70	F	F		
K1	432-12	Relay	S-311-P-2(06)	.063		70	F	F		
CR1	TX1X645	Diode	Mil-S-19500/270C	.08	10%	70	F	F		
CR2	"	"	"	.08	10%	70	F	F		
Q1	TX2N3821	Transistor	Mil-S-19500/375A	.01	25%	70	F	F		

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Preamp Radiometer PC 716
Schematic No. 3436-J-2163
Drawing No. &
Parts List No. 3436-F-2002

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
Q2	TX2N3251A	Transistor	Mil-S-19500/323A	.01	25%	70	F	F		
Q5	"	"	"	.01	25%	70	F	F		
Q8	"	"	"	.01		70	F	F		
Q9	"	"	"	.01		70	F	F		
Q12	"	"	"	.01		70	F	F		
Q3	TX2N2920	Transistor	Mil-S-19500/355A	.01	25%	70	F	F		
Q6	"	"	"	.01	25%	70	F	F		
Q4	TX2N4857	Transistor	Mil-S-19500/385	.01	25%	70	F	F		
Q7	"	"	"	.01	25%	70	F	F		
Q10	TX2N2369A	Transistor	Mil-S-19500/317D	.01	25%	70	F	F		
Q11	"	"	"	.01	25%	70	F	F		
Q13	"	"	"	.01	25%	70	F	F		
Q14	"	"	"	.01	10%	70	PF	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	COMPLETELY REVISED	8/28/72	P.O.
		1-19-73	WP
B	Revised per DCN 3436-D-2176 A1	1-30-73	WP
C	Revised per DCN 3436-D-2176 A2	9-24-73	WP
D	Revised per DCN PL3436-D-2176-D1		

Status of Revision of Each Sheet

1	2	3	4	5
A	A	A	A	A
B	B	B	B	B
C	C	C	C	C
D	D	D	D	D

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	JH	9-21-72
PROJECT ENGR.		
APPROVED	D J Hill	9-27-72
CONTRACTOR APPROVAL		DATE

NEXT ASSY	USED ON
3436-D-2183	

APPLICATION

TITLE
OSCILLATOR CARD
HELIOS RADIOMETER
EXPERIMENT 5C PC730

CODE IDENT 00615 | DWG NO. 3436-D-2176 | REV D

CONTRACT NO. NAS 5-11396 | SHEET 1 OF 5

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WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: OSCILLATOR CARD
HELIOS RADIOMETER
EXPERIMENT 5C PC 730

PL 3436-D-2176-1

REV A

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			3436-D-2188-1	Hybrid Oscillator A1	WTA 76B
2	1			3436-D-2188-2	Hybrid Oscillator A2	WTA 76B
3	1			3436-D-2188-3	Hybrid Osicllator A3	WTA 76B
4	1			3436-D-2188-4	Hybrid Osicllator A4	WTA 76B
5	1			RHA5	Crystal, Y1 26.5 KHz	WTA 20611A
6	1			RHA5	Crystal, Y2 50 KHZ	WTA 20611A
7	1			RHA5	Crystal, Y3 65 KHz	WTA 20611A
8	1			RHA5	Crystal, Y4 85 KHz	WTA 20611A
9	1			RCR07G203JS	Resistor, R18	MIL-R-39008/1
10	1			TX2N2369A	Transistor, Q8	MIL-S 19500/317D
11	1			CKR06BX105KS	Capacitor, C15	MIL-C-39014/2

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WASHINGTON TECHNOLOGICAL ASSOCIATES, INC. 979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852 *Subsidiary of Quanta Systems Corporation*	Title: OSCILLATOR CARD HELIOS RADIOMETER EXPERIMENT 5C PC 730	PL 3436-D-2176-2	REV
	Symbols: T - TOTAL QUANTITY OR RECURRING ITEM; B - BULK MATERIAL; SC - SOURCE CONTROL DWG; SPC - SPECIFICATION CONTROL		Sh Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			3436-D-2188-5	Hybrid Oscillator A5	WTA 76B
2	1			3436-D-2188-6	Hybrid Oscillator A6	WTA 76B
3	1			3436-D-2188-7	Hybrid Oscillator A7	WTA 76B
4	1			3436-D-2188-8	Hybrid Oscillator A8	WTA 76B
5	1			RHA5	Crystal, Y5 115 KHz	WTA 2061
6	1			RHA5	Crystal, Y6 150 KHz	WTA 2061
7	1			RHA5	Crystal, Y7 195 KHz	WTA 2061
8	1			RHA5	Crystal, Y8 255 KHz	WTA 2061
9	1			TX2N3251A	Transistor, Q4	MIL-S-19500/323
10	3			RCR07G203JS	Resistor, R19, R6, R20	MIL-R-3900 /1
11	1			TX2N2369A	Transistor, Q9	MIL-S-19500/317
12	1			CKR06BX105KS	Capacitor, C16	MIL-C-39014/2

WTA

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: OSCILLATOR CARD
HELIOS RADIOMETER
EXPERIMENT 5C PC 730

PL 3436-D-2176-3

REV A

Sh
Dwg

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			3436-D-2188-9	Hybrid Oscillator A9	WTA 76B
2	1			3436-D-2188-10	Hybrid Oscillator A10	WTA 76B
3	1			3436-D-2188-11	Hybrid Oscillator A11	WTA 76B
4	1			3436-D-2188-12	Hybrid Oscillator A12	WTA 76B
5	1			RHA5	Crystal, Y9 340KHz	WTA 20611
6	1			RHA5	Crystal, Y10 445 KHz	WTA 20611
7	1			RHA5	Crystal, Y11 585 KHz	WTA 20611
8	1			RHA5	Crystal, Y12 765 KHz	WTA 20611
9	1			TX2N2351A	Transistor, Q1	MIL-S-19500/323A
10	3			RCR07G203JS	Resistor, R1, R2, R5	MIL-R-39008
11	1			TX2N2369A	Transistor Q3	MIL-S-19500-312D
12	1			CKR06BX105KS	Capacitor, C1	MIL-C-39014

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: HELIOS RADIOMETER EXPERIMENT 5C PC 730

PL 3436-D-2176-4

REV

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			3436-D-2188-13	Hybrid Oscillator A13	WTA 76B
2	1			3436-D-2188-14	Hybrid Oscillator A14	WTA 76B
3	1			3436-D-2188-15	Hybrid Oscillator A15	WTA 76B
4	1			3436-D-2188-16	Hybrid Oscillator A16	WTA 76B
5	1			RHA5	Crystal, Y13 1.010 MHz	WTA 20611
6	1			RHA5	Crystal, Y14 1.320 MHz	WTA 20611
7	1			RHA5	Crystal, Y15 2.280 MHz	WTA 20611
8	1			RHA5	Crystal, Y16 3.000 MHz	WTA 20611
9	1			TX2N3251A	Transistor, Q2	
10	2			RCR07G203JS	Resistor, R3, R4	

W.T.I. Job No. 3436-002
Contract NAS5-11356

Failure Mode and Effects Analysis

Title: Oscillator Card PC 730
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2176-1

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure: Open	Effect of Failure: Short	Effect of Failure: Other	Remarks/Notes
A 1	3436-D-2188-1	Hybrid Oscillator	WTA 76B	.16		70	F	F		
A2	3436-D-2188-2	Hybrid Oscillator	WTA 76 B	.16		70	F	F		
A3	3436-D-2188-3	Hybrid Oscillator	WTA 76 B	.16		70	F	F		
A4	3436-D-2188-4	" "	WTA 76 B	.16		70	F	F		
				.16						
Y 1	RHA 5	Crystal	WTA 20611A	.16		70	F	F		
Y2	RHA 5	Crystal	WTA 20611A	.16		70	F	F		
Y3	RHA 5	"	"	.16		70	F	F		
Y4	RHA 5	"	"	.16		70	F	F		
R18	RCR07G203JS	Resistor	Mil-R-39008/1	.001		70	F	F		
Q8	TX2N2369A	Transistor	Mil-S-19500/317D	.01		70	F	F		
C15	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001		70	F	F		

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W[illegible]A Job No. 3436-0[illegible]
Contract NAS5-[illegible]396

Failure Mode and Effects Analysis

Title Oscillator Card 2 PC 730
Schematic No. 3436-J-2163
Drawing No.& Parts List No. 3436-D-2176-2

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp.° C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
A5	3436-D-2188-5	Hybrid Oscillator	WTA 76 B	.16		70	F	F		
A6	3436-D-2188-6	" "	"	.16		70	F	F		
A7	3436-D-2188-7	" "	"	.16		70	F	F		
A8	3436-D-2188-8	" "	"	.16		70	F	F		
Y 5	RHA 5	Crystal	WTA 20611 A	.2		70	F	F		
Y6	"	"	" "	.2		70	F	F		
Y7	"	"	" "	.2		70	F	F		
Y8	"	"	" "	.2		70	F	F		
Q4	TX2N3251A	Transistor	Mil-S-19500/323A	.01		70	F	F		
R19	RCR07G203JS	Resistor	Mil-R-39008/1	.001		70	F	F		
R6	"	"	"	.001		70	F	F		
R20	"	"	"	.001		70	F	F		
Q9	TX2N2369A	Transistor	Mil-S-19500/317D	.01		70	F	F		
C16	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001		70	F	F		

W[illegible] Job No. 3436-0[illegible]2
Contract NAS5-113[illegible]

Failure Mode and Effects Analysis

Title Oscillator Card 3 PC 730

E=Estimate

Schematic No. 3436-J-2163
Drawing No. &
Parts List No. 3436-D- 2176-3

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
A9	3436-D-2188-9	Hybrid Oscillator	WTA 76 B	.16		70	F	F		
A10	3436-D-2188-10	" "	"	.16		70	F	F		
A11	3436-D-2188-11	" "	"	.16		70	F	F		
A12	3436-D-2188-12	" "	"	.16		70	F	F		
Y9	RHA 5	Crystal	WTA 20611 A	.2		70	F	F		
Y10	"	"	" "	.2		70	F	F		
Y11	"	"	" "	.2		70	F	F		
Y12	"	"	" "	.2		70	F	F		
Q1	TX2N3251A	Transistor	Mil-S-19500/323A	.01		70	F	F		
R1	RCR07G203JS	Resistor	Mil-R-39008/1	.001		70	F	F		
R2	"	"	"	.001		70	F	F		
R5	"	"	"	.001		70	F	F		
Q3	TX2N2369A	Transistor	Mil-S-19500/312B	.01		70	F	F		
C1	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001		70	F	F		

W. A Job No. 3436-032
Contract NAS5-11358

Failure Mode and Effects Analysis

Title Oscillator Card 4 PC 730

Schematic No. 3436-J-2163

Drawing No. & Parts List No. 3436-D-2176 -4

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure: Open	Short	Other	Remarks/Notes
A13	3436-D-2188-13	Hybrid Oscillator	WTA 76 B	.16		70	F	F		
A14	3436-D-2188-14	" "	"	.16		70	F	F		
A15	3436-D-2188-15	" "	"	.16		70	F	F		
A16	3436-D-2188-16	" "	"	.16		70	F	F		
Y13	RHA 5	Crystal	WTA 20611A	.2		70	F	F		
Y14	RHA 5	Crystal	WTA 20611A	.2		70	F	F		
Y15	RHA 5	Crystal	WTA 20611A	.2		70	F	F		
Y16	RHA 5	Crystal	WTA 20611A	.2		70	F	F		
Q2	TX2N3251A	Transistor	Mil-S-19500/323A	.01		70	F	F		
RQ	RCR07G203JS	Resistor	Mil-R-39008/1	.001		70	F	F		
R4	"	"	"	.001		70	F	F		

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LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1, Completely Revised	9/21/72	[illegible]
B	Revised per DCN PL3436-D-2169-A2	11-22-72	[illegible]
C	Change P/N of Item 24 from RM741	3-7-73	[illegible]
D	Revision per DCN PL3436-D-2169 D1	10-3-73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A	A																																						
B	B	B																																						
C	B	C																																						
D	—	D																																						

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	[illegible]	9-21-72
PROJECT ENGR.	[illegible]	9-27-7[illegible]
APPROVED	[illegible]	9-27-72
CONTRACTOR APPROVAL		DATE

NEXT ASSY	USED ON
3436-D-2183	

APPLICATION

TITLE AGC AMPLIFIER, HELIOS RADIOMETER EXPERIMENT 5C, PC724

CODE IDENT	DWG NO.	REV
00615	3436-D-2169	D

CONTRACT NO. NAS 5-11396 SHEET 1 OF 3

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC. 979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852 *Subsidiary of Quanta Systems Corporation*	Title: AGC AMPLIFIER HELIOS RADIOMETER EXPERIMENT 5C, PC 724	PL 3436-D-2169	A REV
	Symbols: T - TOTAL QUANTITY OR RECURRING ITEM; B - BULK MATERIAL; SC - SOURCE CONTROL DWG; SPC - SPECIFICATION CONTROL		Sh Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	8			CKR06BX103KS	Capacitor, C1, C2, C4, C5, C6, C7, C11, C12	MIL-C-39014/2
2	1			CKR06BX105KS	Capacitor, C3	MIL-C-39014/2
3	2			CKR05BX101KS	Capacitor	MIL-C-39014/1
4	1			CKR05BX121KS	Capacitor, C13	MIL-C-39014/1
5	1			CKR05BX102KS	Capacitor, C10	MIL-C-39014/1
6	1			RLR07C301JS	Resistor, R1	MIL-R-39017/1
7	2			RLR07C103JS	Resistor, R2, R3	MIL-R-39017/1
8	1			RCR07G104JS	Resistor, R4	MIL-R-39008/1
9	1			RLR07C512JS	Resistor, R5	MIL-R-39017/1
10	1			RCR07G JS	Resistor, R6	MIL-R-3900 /1
11	1			RCR07G394JS	Resistor	
12	1			RCR07G104JS	Resistor, R8	
13	1			RCR07G475JS	Resistor, R9	
14	1			RCR07G623JS	Resistor, R10	
15	1			TX1N645	Diode, CR1, CR2	
16	2			JANTX1N5711	Diode, CR3, CR4	
17	1			TX2N4857	Transistor, (FET), Q1	
18	1			TX2N2369	Transistor, Q2	

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: AGC AMPLIFIER
HELIOS RADIOMETER
EXPERIMENT 5C PC 724

PL 3436-D-2169

REV A

Sh
Dwg

Symbols
T – TOTAL QUANTITY OR RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
19	1			TX2N3251	Transistor, Q3	MIL-S-19500/395
20	1			MC-1552GH2	Integrated Circuit, A1	WTA20610G
21	1			RM741	Integrated Circuit, A2	WTA SPEC. 23755

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WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

E=Estimate

Title AGC Amplifier PC 724
Schematic No. 3436-J-2163
Drawing No.& Parts List No. 3436-D-2169 Page 1 of 2

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated To % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
C-1	CKR06BX103KS	Capacitor	Mil-C-39014/2	.001	02%	70°	PF	F		
C-2	"	"	"	.001	25%	70°	PF	F		
C-4	"	"	"	.001	02%	70°	PF	PF		
C-5	"	"	"	.001	20%	70°	PF	F		
C-6	"	"	"	.001	20%	70°	PF	F		
C-7	"	"	"	.001	02%	70°	PF	PF		
C-11	"	"	"	.001	10%	70°	PF	PF		
C-12	"	"	"	.001	20%	70°	PF	PF		
C-3	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	10%	70°	F	F		
C-8	CKR05BX101KS	"	Mil-C-39014/1	.001	20%	70°	F	F		
C-9	"	"	"	.001	10%	70°	F	F		
C-13	CKR05BX121KS	Capacitor	Mil-C-39014/1	.001	20%	70°	F	F		
C-10	CKR05BX102KS	"	"	.001	10%	70°	PF	F		
R-1	RLR07C301JS	Resistor	Mil-C-39017/1	.001	10%	70°	F	F		
R-2	RLR07C103JS	"	"	.001	10%	70°	F	F		
R-3	"	"	"	.001	10%	70°	F	F		
R-4	RCR07G104JS	Resistor	Mil-R-39008/1	.001	01%	70°	F	F		
R-5	RLR07C512JS	"	Mil-R-39017/1	.001	01%	70°	F	F		
R-6	RCR07G JS	"	Mil-R-39008/1	.001	10%	70°	F	F		Value to be Determined
R-7	RCR07G394JS	"	"	.001	10%	70°	F	F		
R-8	RCR07G104JS	"	Mil-R-39008/1	.001	01%	70°	F	F		
R-9	RCR07G475JS	"	"	.001	01%	70°	F	F		
R-10	RCR07G623JS	"	"	.001	01%	70°	F	F		

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title: AGC Amplifier PC 724
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2169 Page 2 of 2

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated To % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
CR 1	TX1N645	Diode	Mil-S-19500/270	.01	10%	70°	F	F		
CR 2	"	"	"	.01	10%	70°	F	F		
CR 3	JANTX1N5711	Diode	Mil-S-19500/444	.01	10%	70°	F	F		
CR 4	"	"	"	.01	10%	70°	F	F		
Q 1	TX2N4857	Transistor	Mil-S-19500/385	.01	10%	70°	F	F		
Q 2	TX2N2369	"	Mil-S-19500/317	.01	50%	70°	F	F		
Q 3	TX2N3251	"	Mil-S-19500/323	.01	50%	70°	F	F		
A-1	MC1552GH2	Integrated Circuit	WTA 20610G	.08		70°	F	F		
A-2	RM 741	" "	WTA 23755	.08		70°	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1 and Items 6, 7, 8, 9, and 10	9/6/72	Odarchenko
B	Revised per DCN PL3436-D-2174-A1 and PL3436-D-2174-A2	11-13-72	P.O.
C	Revised per DCN PL3436-D-2174 B1	1-19-73	[illegible]
D	Revised per DCN PL3436-D-2174 – C1	3-7-73	[illegible]
E	Revised per DCN 3436-D-2175-C1	9/11/73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							
C	C																																							
D	D																																							
E	E																																							

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	JH	7-5-72
PROJECT ENGR.	[illegible]	9-11-72
APPROVED	[illegible]	9-27-72

CONTRACTOR APPROVAL DATE

NEXT ASSY	USED ON
3435-D-2183	

APPLICATION

TITLE LOGIC CARD 2, HELIOS RADIOMETER PC ASSEMBLY (PC 728) EXPERIMENT 5C

CODE IDENT	DWG NO.	REV
00615	PL 3436-D-2174	E

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: LOGIC CARD 2, HELIOS RADIOMETER EXPERIMENT 5C, PC 728

PL 3436-D-2174

REV A

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	2			RCR07G103JS	Resistor, R61, R61	MIL-R-39008/1
2	2			CKR06 - - -JS	Capacitor, C40, C41	
3	3		01295	SN54L10F1	Integrated Circuit, A11, A13, A14	MSFC SPEC 85MO376
4	1		01295	SN54L73F1	Integrated Circuit, A10	MSFC SPEC 85MO376
5	2		01295	SN54L00F1	Integrated Circuit, A12, A16	MSFC SPEC 85MO376
6	1			RCR07G393JS	Resistor, R85	MIL-R-39008/1
7	1			CKR05BX221KS	Capacitor, C51	MIL-C-39014/1

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Logic Card 2 PC 728
Schematic No. 3436-J-2163
Drawing No.
Parts List No. 3436-D-2174 Page 1 of 1

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp.°C.	Effect of Failure Open	Short	Other	Remarks/Notes
R61	RCR07G103JS	Resistor	Mil-R-39008/1	.001	3%	70	F	F		
R62	"	"	"	.001	3%	70	F	F		
C40	CKR06 JS	Capacitor	Mil-C-39014/2	.001	25%	70	F	F		TBD
C41	"	"	"	.001	25%	70	F	F		TBD
A11	SN54L10F1	Integrated Circuit	MSFC Spec. - 85MO376	.02		70	F	F		
A13	"	"	"	.02		70	F	F		
A14	"	"	"	.02		70	F	F		
A10	SN54L73F1	Integrated Circuit	MSFC Spec. 85MO376	.02		70	F	F		
A12	SN54L00F1	Integrated Circuit	" "	.02		70	F	F		
A16	"	" "	" "	.02		70	F	F		
R85	RCR07G393JS	Resistor	Mil-R-39008/1	.001	2%	70	F	F		
C51	CKR05BX221KS	Capacitor	Mil-C-39014/1	.001	25%	70	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1, CR23 to Item 6, R86 to Item 11 Deleted R46 from Item 2, R72 from Item 3, CR19, CR16, CR15, CR20, and CR21 from Item 6 Added Items 12 through 14	9/6/72	Odarchenko
B	Revised per DCN PL3436-D-2173-A1 and DCN PL3436-D-2173-A2	11/13/72	[illegible]
C	Revised per DCN PL3436-D-2173-A3	1/15/73	[illegible]
D	Revised per DCN PL3436-D-2173-A4	1/30/73	[illegible]
E	Revised per DCN PL3436-D-2173-E1	5/15/73	[illegible]
F	Revised per DCN PL3436-D-2173-F1	9/19/73	[illegible]
G	Revised per DCN PL3436-D-2175-G1	12/2/73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A	A																																						
B	B	–																																						
C	C	–																																						
D	D	–																																						
E	E	E																																						
F	F	–																																						
G	G	–																																						

NEXT ASSY	USED ON
3436-D-2183	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	NH	9-9-72
PROJECT ENGR.	G WARD	9-11-72
APPROVED	D L Gloo	9-27-72

CONTRACTOR APPROVAL | DATE

TITLE
LOGIC CARD I, HELIOS RADIOMETER
PC ASSEMBLY (PC 727) EXPERIMENT 5C

CODE IDENT	DWG NO.	REV
00615	PL 3436-D-2173	G

CONTRACT NO. NAS 5-11396 | SHEET 1 OF 2

ASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: LOGIC CARD 1, HELIOS RADIOMETER EXPERIMENT 5C, PC727

FL 3436-D-2173

REV G

Sh 2 Dwg

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	2			RCR07G203JS	Resistor 20K, 1/4w, 5%, R69, R70	MIL-R-39008/1
2	1			RCR07G103JS	Resistor 10K, 1/4w, 5%, R71	MIL-R-39008/1
3	6			RCR07G104JS	Resistor 100K, 1/4w, 5%, R47, R48, R73, R74, R75, R76	MIL-R-39008/1
4	1			RCR07G100JS	Resistor 10 ohms, 1/4w, 5%, R58	MIL-R-39008/1
5	2			CKR06BX105KS	Capacitor, 1 uf, 50V, 10%, C37, C45	MIL-C-39014/2
6	1			TX1N645	Diode, CR14	MIL-S-19500/240C
7	1			TX1N750	Diode, Zener, CR23	MIL-S-19500/127
8	3			TX2N2369A	Transistor, NPN, Q14, Q15, Q16	MIL-S-19500/317
9	3			TX2N3251A	Transistor, PNP, Q11, Q12, Q13	MIL-S-19500/323
10	1			SN54L01F1	Integrated Circuit, A9	MSFC SPEC 15MO3766
11	1			RCR07G153JS	Resistor, 15K, 1/4w, 5%, R86	MIL-R-39008/1

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

E=Estimate

Title Logic Card 1 PC 727
Schematic No. 3436-J-2163
Drawing No.
Parts List No. 3436-D-2173 Page 1 of 2

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
R69	RCR07G203JS	Resistor	Mil-R-39008/1	.001	3%	70	F	F		
R70	"	"	"	.001	1%	70	F	F		
R71	RCR07G102JS	Resistor	Mil-R-39008/1	.001	3%	70	F	F		
R51	"	"	"	.001	3%	70	F	F		
R44	RCR07G104JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		
R45	"	"	"	.001	1%	70	F	F		
R47	"	"	"	.001	1%	70	F	F		
R48	"	"	"	.001	1%	70	F	F		
R50	"	"	"	.001	1%	70	F	F		
R73	"	"	"	.001	1%	70	F	F		
R74	"	"	"	.001	1%	70	F	F		
R75	"	"	"	.001	1%	70	F	F		
R76	"	"	"	.001	1%	70	F	F		
R58	RCR07G100JS	Resistor	Mil-R-39008/1	.001	20%	70	F	F		
C37	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	25%	70	PF	F		
C45	"	"	"	.001	25%	70	PF	F		
CR13	TX1N645	Diode	Mil-S-19500/240C	.01	10%	70	F	F		
CR14	"	"	"	.01	10%	70	F	F		
CR23	"	"	"	.01	20%	70	F	F		
CR18	TX1N756A	Diode	Mil-S-19500/127	.01	20%	70	F	F		

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Logic Card ; PC 727
Schematic No. 3436-D-2163
Drawing No.
Parts List No. 3436-D-2173 Page 2 of 2

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
Q14	TX2N2369A	Transistor	Mil-S-19500/317	.01	20%	70	F	F		
Q15	"	"	"	.01	20%	70	F	F		
Q16	"	"	"	.01	20%	70	F	F		
Q11	TX2N3251A	Transistor	Mil-S-19500/323	.01	20%	70	F	F		
Q12	"	"	"	.01	20%	70	F	F		
Q13	"	"	"	.01	20%	70	F	F		
A9	SN54L01F1	Integrated Circuit	MSFC Spec. 85MO3766	.02		70	F	F		
R53	RCR07G393JS	Resistor	Mil-R-39008/1	.001	3%	70	F	F		
R86	"	"	"	.001	1%	70	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1 and Items 13, 14, and 15	9/6/72	Odarchenko
B	Revised per DCN PL3436-D-2175 A1	1-30-73	NP
C	Revised per DCN 3436-D-2175-C1	11-9-73	NP

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							
C	C																																							

NEXT ASSY	USED ON
3436-D-2183	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	NH	9-9-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	D J Hill	9-27-72
CONTRACTOR APPROVAL		DATE

TITLE LOGIC CARD 3, HELIOS RADIOMETER EXPERIMENT 5C (PC 726)

CODE IDENT	DWG NO.	REV
00615	PL 3436-D-2175	C

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
973 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: LOGIC CARD 3, HELIOS RADIOMETER EXPERIMENT 5C PC 726

PL 3436-D-2175 | REV C | Sh 2 Dwg

Symbols
T – TOTAL QUANTITY OR RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			RCR07G513JS	Resistor, 51K, 1/4W, 5%, R54	MIL-R-39008/1
2	3			RCR07G512JS	Resistor, 5.1K, 1/4W, 5%, R56, R59, R60	MIL-R-39008/1
3	2			RCR07G- - S	Resistor, TBD, 1/4W, 5%, , R55	MIL-R-39008/1
4	2			RCR07G100JS	Resistor, 10 ohms, 1/4W, 5%, R63, R64	MIL-R-39008/1
5	3			RLR07CS - -S	Resistor, TBD, 1/4W, 5%, R65, R66, R67	MIL-R-39017/1
6	2			CKR05BX470KS	Capacitor, 47 pf, 200V, 10%, C33, C34	MIL-C-39014/1
7	1			CSR13E107KS	Capacitor, 100 uf, 20V, 10%, C35	MIL-C-39003/1
8	1			CKR05- - - S	Capacitor, TBD C36	MIL-C-39014/1
9	2			CKR06BX105KS	Capacitor, 1 uf, 100V, 10%, C38, C39	MIL-C-39014/2
10	6			TX1N645	Diode, CR7, CR9, CR10, CR11, CR12, CR8	MIL-S-19500/240C
11	1		01295	SN54L00F1	Integrated Ckt., A15	MSFC SPEC 85MC3766
12	2			RM741	Integrated Ckt., A17, A18	WTA SPEC 23755

ORIGINAL PAGE IS OF POOR QUALITY

W.E. Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

E=Estimate

Title: Logic Card 3
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2175

Page 1 of 2

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C	Effect of Failure Open	Short	Other	Remarks/Notes
R54	RCR07G513JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		
R56	RCR07G512JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		
R59	"	"	"	.001	10%	70	F	F		
R60	"	"	"	.001	10%	70	F	F		
R57	RCR07G S	Resistor	Mil-R-39008/1	.001	10%	70	F	F		TBD
R55	"	"	"	.001	10%	70	F	F		TBD
R63	RCR07G100JS	Resistor	Mil-R-39008/1	.001	5%	70	F	PF		
R64	"	"	"	.001	5%	70	F	PF		
R65	RLR07CS S	Resistor	Mil-R-39017/1	.001	1%	70	F	F		TBD
R66	"	"	"	.001	5%	70	F	F		TBD
R67	"	"	"	.001	1%	70	F	F		TBD
C33	CKR05BX470KS	Capacitor	Mil-C-39014/1	.001	2%	70	F	F		
C34	"	"	"	.001	2%	70	F	F		
C35	CSR13E107KS	Capacitor	Mil-C-39003/1	.001	25%	70	PF	F		
C36	CKR05 S	Capacitor	Mil-C-39014/1	.001	2%	70	F	F		TBD
C38	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	25%	70	PF	F		
C39	"	"	"	.001	25%	70	PF	F		
CR7	TXIN645	Diode	Mil-S-19500/240C	.01	10%	70	F	F		
CR9	"	"	"	.01	10%	70	F	F		
CR10	"	"	"	.01	10%	70	F	F		
CR11	"	"	"		10%	70				

Failure Mode and Effects Analysis

Title: Logic Card 3 PC 726

Schematic No. 3436-J-2163

Drawing No. & Parts List No. 3436-D-2175

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
CR12	TX1N645	Diode	Mil-S-19500/240C	.01	10%	70	F	F		
CR8	"	"	"	.01	10%	70	F	F		
A15	SN54L00F1	Integrated Circuit	MSFC Spec. - 85MO3766	.02		70	F	F		
A17	RM 741	Integrated Circuit	WTA Spec. 23755	.02		70	F	F		
A18	"	" "	"	.08	[illegible]	70	F	F		

ORIGINAL PAGE IS OF POOR QUALITY

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Revised per DCN PL3436-D-2252-1	11-14-72	[illegible]
B	Delete R111 from Item 7 - Add to Item 8	3-7-73	[illegible]
C	Revised per DCN PL3436-D-2252-C1	9/24/73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							
C	C																																							

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	JH	9-27-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	9-29-72

CONTRACTOR APPROVAL — DATE

NEXT ASSY	USED ON
3436-D-2171	

APPLICATION

TITLE: IF, HELIOS RADIOMETER EXPERIMENT 5C (PC784)

CODE IDENT: 00615 — DWG NO.: 3436-D-2252 — REV: C

CONTRACT NO. NAS 5-11396 — SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: IF HELIOS RADIOMETER EXPERIMENT 5C (PC784)

PL 3436-D-2252

REV C

Sh 2 Dwg

Symbols
T – TOTAL QUANTITY OR RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			MS90537-19	Coil RF, 3.3 UH, L4	LT4K242 MIL-C-15305
2	2			MC1552GH2	Integrated Circuit A3, A19	WTA 20610
3	2			CM KS	Capacitor (TBD), C50, C23	
4	2			CKR05BX101KS	Capacitor, 100 pf @ 200 V, 10%, C17, C21	MIL-C-39014/1
5	5			CKR05BX104KS	Capacitor, .1 UF @ 50 V, 10%, C19 C54, C55, C56, C57	MIL-C-39014/1
6	2			CKR06BX105KS	Capacitor, 1 UF @ 50 V, 10%, C18, C20	MIL-C-39014/2
7	7			RCR07G JS	Resistor, (TBD), R28, R95, R107, R108, R109, R110, R113	MIL-R-39008/1
8	2			RCR07G100JS	Resistor, 10 ohms, 1/4w, 5%, R25, R111	MIL-R-39008/1
9	1			RCR07G751JS	Resistor, 750 ohms, 1/4w, 5%, R23	MIL-R-39008/1
10	3				Thermistor (TBD), R91, R112 R114	

Failure Mode and Effects Analysis

E=Estimate

Title IF PC 784
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2252

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp° C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
L 4	MS 90537-19	Coil, RF		.001	20%	70	PF	F		
A3	MC1552GH2	Integrated Circuit	WTA 20610	.08		70	F	F		
C50	CKR05BX KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	F		TBD
C23	"	"	"	.001	10%	70	PF	F		TBD
C17	CKR05BX101KS	Capacitor	Mil-C-39014/1	.001	3%	70	F	F		
C21	"	"	"	.001	3%	70	F	NF		
C19	CKR05BX104KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	F		
C18	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	12%	70	PF	F		
C20	"	"	"	.001	12%	70	PF	F		
R28	RCR07G JS	Resistor	Mil-R-39008/1	.001	10%	70	F	PF		TBD
R95	"	"	"	.001	10%	70	F	PF		TBD
R25	RCR07G100JS	"	"	.001	50%	70	F	PF		
R23	RCR07G751JS	Resistor	Mil-R-39008/1	.001	2%	70	PF	F		TBD
R91		Thermistor		.001	10%	70	PF	PF		

ORIGINAL PAGE IS OF POOR QUALITY

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	COMPLETELY REVISED	9-25-72	JJT
B	Revised Per DCN PL3436-D-2185-1	11/14/72	P.O.

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	JH	9-25-72
PROJECT ENGR.	[illegible]	9-27-72
APPROVED	D J Gall	9-27-72
CONTRACTOR APPROVAL		

NEXT ASSY	USED ON
3436-D-2172	

APPLICATION

TITLE TRANSFORMER BOARD
HELIOS RADIOMETER
EXPERIMENT 5C PC732

CODE IDENT	DWG NO.	REV
00615	3436-D-2185	B

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: TRANSFORMER BOARD
HELIOS RADIOMETER
EXPERIMENT 5C PC732

PL 3436-D-2185

REV B

Sh 2
Dwg

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1	-		SH-79	Transformer, T1	WTA 22344
2	10			RCR07G JS	Resistor, (TBD), 1/4w, 5% R48, R96, R97, R99, R100, R101, R102, R103, R104, R105	MIL-R-39008/1
3	1			RCR07G240JS	Resistor, 24 ohm, 1/4w, 5%, R98	MIL-R-39008/1

WTA Job No. 3436-002
Contract NAS5-11395

Failure Mode and Effects Analysis

Title Transformer Board PC 732
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2185

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
T 1	SH 79	Transformer	WTA 22344	.05	25%	70	F	PF		
R96	RCR07G JS	Resistor	Mil-R-39008/1	.001	20%	70	F	PF		TBD
R97	"	"	"	.001	20%	70	F	PF		TBD
R99	"	"	"	.001	20%	70	F	PF		TBD
R48	"	"	"	.001	20%	70	F	PF		TBD
R98	RCR07G240 JS	Resistor	Mil-R-39008/1	.001	20%	70	F	PF		TBD

ORIGINAL PAGE IS OF POOR QUALITY

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	COMPLETELY REVISED	[illegible]	[illegible]
B	Revised per DCN PL3436-D-2183 -A1, PL3436-D-2183-A2, PL3436-D-2183-A3 and PL3436-D-2183-A4	[illegible]	[illegible]
C	Revised per DCN-3436-D-2183	[illegible]-30-73	[illegible]
D	Revised per DCN 3436-D-2183 D1	[illegible]	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
A	A	—																													
B	B	B																													
C	C	C																													
D	D	D																													

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	[illegible]	[illegible]
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	9-[illegible]-7[illegible]
CONTRACTOR APPROVAL		DATE

NEXT ASSY	USED ON
3[illegible]-D-2172	

APPLICATION

TITLE
MOTHER BOARD PC/31-1
HELIOS RADIOMETER
EXPERIMENT 8C

CODE IDENT	DWG NO.	REV
80815	3436-D-2183-1	D

CONTRACT NO. [illegible] SHEET 1 OF 3

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title MOTHER BOARD PC731-1
HELIOS RADIOMETER
EXPERIMENT 5C

PL 3436-D-2183

D
REV

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh2
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			3436-C-2167	Mixer-Filter -IF Assembly	WTA
2	1			3436-D-2173	Logic Circuit 1, PC727	WTA
3	1			3436-D-2174	Logic Circuit 2, PC728	WTA
4	1			3436-D-2175	Logic Circuit 3, PC726	WTA
5	1			3436-D-2250	Output Circuit, PC729	WTA
6	1			3436-D-2169	AGC Amplifier, PC724	WTA
7	1			3436-D-2176-1	Oscillator, PC730	WTA
8	1			3436-D-2176-2	Oscillator, PC730	WTA
9	1			3436-D-2176-3	Oscillator, PC730	WTA
10	1			3436-D-2176-4	Oscillator, PC730	WTA
11						
12						
13						
14						
15	1			RCR07G333JS	Resistor, 33K, 1/4W, 5%, R77	MIL-R-39008/1
16	2			RCR07G243JS	Resistor, 24K, 1/4W, 5%, R78, R82	MIL-R-39008/1
17	1			RCR07G913JS	Resistor, 91K, 1/4W, 5%, R81	MIL-R-39008/1
18	1			TX1N753A	Diode, CR22	MIL-S-19500/127
19						
20						

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Mother Board PC 731
Schematic No. 3436-J-2163
Drawing No.&
Parts List No. 3436-D-2183

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
R77	RNR55C3482FPS	Resistor	Mil-R-55182/1	.001	1%	70	F	F		
R79	"	"	"	.001	1%	70	F	F		
R78	RNR55C2492FPS	Resistor	Mil-R-55182/1	.001	1%	70	F	F		
R80	"	"	"	.001	1%	70	F	F		
R82	"	"	"	.001	1%	70	F	F		
R81	RNR55C9312FPS	Resistor	Mil-R-55182/1	.001	1%	70	F	F		
CR22	TX1N753A	Diode	Mil-S-19500/127	.01	1%	70	F	F		

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LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	COMPLETELY REVISED AND CHANGED DRAWING NUMBER FROM 3436-D-2163 TO 3436-D-2250	7-27-72	[illegible]
B	REVISED PER DCN PL3436-D-2250-A2	11-14-72	[illegible]
C	Revised per DCN PL3436-D-2250A3		[illegible]
D	Add Item 4	3-7-73	[illegible]
E	Change Find No. 4 from 1/4w to 1/10w	4/24/73	[illegible]
F	Revised per DCN PL3436-2250 F1	5-7-73	[illegible]
G	Revised per DCN PL3436-2250-G1	9/11/73	[illegible]
H	Revised per DCN 3436-D-2175-C1	9/11/73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							
C	C																																							
D	D																																							
E	E																																							
F	–	A																																						
G	–	B																																						
H	–	H																																						

NEXT ASSY	USED ON
3436-D-2183	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
a quanta systems corporation

	NAME	DATE
PREPARED BY	[illegible]	9-25-72
PROJECT ENGR.	[illegible]	
APPROVED	[illegible]	9-27-72

CONTRACTOR APPROVAL DATE

TITLE OUTPUT CARD HELIOS RADIOMETER, EXPERIMENT 5C PC729

CODE IDENT	DWG NO.	REV
00615	3436-D-2250	H

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: OUTPUT CARD
HELIOS RADIOMETER
EXPERIMENT 5C PC729

PL 3436-D-2250

E - REV

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh 2 Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	2			RCR07G100JS	Resistor, 10 ohm, 1/4w, 5%, R35, R58,	MIL-R-39008/1
2	12			RCR07G JS	Resistor, (TBD), R34, R31, R3 , R40, R41, R42, R83, R84, R86, R87, R90, R92	MIL-R-39008/1
3	1			RCR07G102JS	Resistor, 1K, 1/4w, 5%, R37	MIL-R-39008/1
4	1			RNR55JS	Resistor, 845 ohm, 1/10w, 1%, R85	MIL-R-39008/1
5	1			RCR07G JS	Resistor, (TBD), 1/4w, 5%, R38	MIL-R-39008/1
6	1			RCR07G514JS	Resistor, 510K, 1/4w, 5%, R39	MIL-R-39008/1
7	4				Thermistor, (TBD), R101 - R104	
8	4			CKR05BX105KS	Capacitor, 1UF @ 50V, 10%, C30, C32, C1, C2	MIL-C-39014/2
9	1			CKR05BX103KS	Capacitor, .01UF, @ 50V, 10%, C31	MIL-C-39014/2
10	1			TX2N3811	Transistor, Q10	MIL-S-19500/336
11	1			TX2N2605	Transistor, Q11	MIL-S-19500/354
12	3			RM741	Integrated Circuit A7, A8, & A9,	WTA SPEC 23755
13						
14						
15						
16	1			SM54L01F1	Integrated Circuit A5	MSFC85M03766-000
17	1			SM54L00F1	Integrated Circuit A6	MSFC SPEC 85MO3766

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Output Card PC 729
Schematic No. 3436-J-2163
Drawing No.&
Parts List No. 3436-D-2250 Page 1 of 2

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hrs.	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
R-35	RCR07G100JS	Resistor	Mil-R-39008/1	.001	40%	70°	F	PF		
R-88	"	"	"	.001	40%	70°	F	PF		
R-89	"	"	"	001	02%	70°	F	PF		
R-91	"	"	"	.001	02%	70°	F	PF		
R-34	RCR07G JS	Resistor	Mil-R-39008/1	.001	10%	70°	F	F		TBD
R-36	"	"	"	.001	10%	70°	F	F		TBD
R-38	"	"	"	.001	10%	70°	F	F		TBD
R-40	"	"	"	.001	10%	70°	F	F		TBD
R-41	"	"	"	.001	10%	70°	PF	PF		TBD
R-42	"	"	"	.001	10%	70°	PF	PF		TBD
R-83	"	"	"	.001	10%	70°	PF	PF		TBD
R-84	"	"	"	.001	10%	70°	F	PF		TBD
R-86	RCR07G JS	Resistor	Mil-R-39008/1	.001	50%	70°	F	PF		TBD
R-87	"	"	"	.001	10%	70°	F	PF		TBD
R-90	"	"	"	.001	50%	70°	F	PF		TBD
R-92	"	"	"	.001	10%	70°	F	F		TBD
R-37	RCR07G102JS	Resistor	Mil-39008/1	.001	10%	70°	F	PF		
R-85	RCR07G JS	"	"	.001	10%	70°	F	F		TBD
R-32	RCR07G JS	"	"	.001	10%	70°	F	F		TBD
R-39	RNR55C4993FF	"	Mil-R-55182/1	.1	01%	70°	F	F		
R-95		Thermistor		.021	20%	70°	F	F		TBD
R-96		Thermistor		.021	20%	70°	F	F		TBD
R-97		Thermistor		.021	20%	70°	F	F		TBD
R-98		Thermistor		.021	20%	70°	F	F		TBD
C-30	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	15%	70°	PF	F		
C-32	"	"	"	.001	15%	70°	PF	F		
C-31	CKR06BX103KS	"	"	.001	10%	70°	PF	F		

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title: Output Card PC 729
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2250

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hrs.	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp.°C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
Q-10	TX2N3811	Transistor	Mil-S-19500/336	.01	10%	70°	F	F		
Q-11	TX2N2605	Transistor	Mil-S-19500/354	.01	40%	70°	F	F		
A-7	RM 741	Integrated Circuit	WTA 23755	.08		70°	F	F		
A-8	"	" "	"	.08		70°	F	F		
A-9	"	" "	"							
A-5	SM54L00F1	Integrated Circuit	MSFC85M03766/000	0.08		70°	F	F		
A-6	"	" "	"	.06		70°	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1, Item 7, 8	8-22-72	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							

NEXT ASSY	USED ON
3436-D2179	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	[illegible]	8-22-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	8-22-72

CONTRACTOR APPROVAL DATE

TITLE Noise Source Switching Welded Module Helios Radiometer Experiment 5C

CODE IDENT	DWG NO.	REV
00615	WM 222	A

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: Noise Source Switching Welded Module Helios Experiment 5C

PL WM 222

REV A

Sh 2 Dwg

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			TX2N2907A	Transistor, FET, Q10	MIL-S-19500/291B
2	1			TX2N3251A	Transistor, PNP, Q11	MIL-S-19500/323A
3	1			TX2N2222A	Transistor, NPN, Q12	MIL-S-19500/255E
4	1			TX1N645	Diode, CR6	MIL-S-19500/240C
5	4			CBD 1045	Resistor, 100K 1/4w 5%, R27, R28, R29, R31	Allen Bradley
6	1			CBD 1035	Resistor, 10K 1/4w 5%, R30	Allen Bradley
7	Ref					
8	Ref					

ORIGINAL PAGE IS OF POOR QUALITY

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title: Noise Source Switching
Schematic No. 3463-J-2163
Drawing No. & Parts List No. WM 222

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
Q10	TX2N2907A	Transistor	Mil-S-19500/291B	.01	30%	70	F	F		
Q11	TX2N3251A	Transistor	Mil-S-19500/323A	.01	20%	70	F	F		
Q12	TX2N2222A	Transistor	Mil-S-19500/255B	.01	30%	70	F	F		
CR6	TX1N645	Diode	Mil-S-19500/240C	.01	5%	70	F	F		
R27	CBD 1045	Resistor	Allen Bradley	.001	1%	70	F	F		
R28	"	"	"	.001	1%	70	F	F		
R29	"	"	"	.001	1%	70	F	F		
R31	"	"	"	.001	3%	70	F	F		
R30	CBD 1035	Resistor	Allen Bradley	.001	1%	70	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1, Item 5, 6	8-22-72	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							

NEXT ASSY	USED ON
3436-D-2179	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	NH	8-22-72
PROJECT ENGR.	[illegible]	8-22-72
APPROVED	[illegible]	8-29-72

CONTRACTOR APPROVAL DATE

TITLE Noise Source Switching
Welded Module
Helios Roadimeter
Experiment 5C

CODE IDENT	DWG NO.	REV
00615	WM 223	A

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: Noise Source Switching Welded Module Helios Experiment 5C

PL WM 223

REV A

Sh 2 Dwg

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	3			TX2N3251A	Transistor, PNP, Q13, Q14, Q16	MIL-S-19500/323/A
2	7			CBD 1045	Resistor, 100K 1/4w 5%, R32, R33, R34, R35, R36, R40, R41	Allen Bradley
3	1			CBD 1035	Resistor, 10K 1/4w 5%, R42	Allen Bradley
4	7			TX1N645	Diode, CR7, CR8, CR10, CR14, CR16, CR17, CR18	MIL-S-19500/240C
5	Ref					
6	Ref					

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Noise Source Switching
Schematic No. 3436-J-2163
Drawing No. & Parts List No. WM 223

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp.°C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
Q13	TX2N3251A	Transistor	Mil-S-19500/323A	.01	3%	70	F	F		
Q14	"	"	"	.01	3%	70	F	F		
Q16	"	"	"	.01	3%	70	F	F		
R32	CBD 1045	Resistor	Allen Bradley	.001	1%	70	F	F		
R33	"	"	"	.001	1%	70	F	F		
R34	"	"	"	.001	1%	70	F	F		
R35	"	"	"	.001	1%	70	F	F		
R36	"	"	"	.001	1%	70	F	F		
R40	"	"	"	.001	1%	70	F	F		
R41	"	"	"	.001	1%	70	F	F		
R42	CBD 1035	Resistor	Allen Bradley	.001	1%	70	F	F		
CR7	TX1N645	Diode	Mil-S-19500/240C	.01	5%	70	F	F		
CR8	"	"	"	.01	5%	70	F	F		
CR10	"	"	"	.01	5%	70	F	F		
CR14	"	"	"	.01	5%	70	F	F		
CR16	"	"	"	.01	5%	70	F	F		
CR17	"	"	"	.01	5%	70	F	F		
CR18	"	"	"	.01	5%	70	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1, Items 11, 12, and 13, 14	8/14/7[illegible]	JMJ

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

TITLE Noise Source Switching Helios
Radiometer
PC Assembly (PC 725)
Experiment 5C

	NAME	DATE
PREPARED BY	JNH	9-22-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	9-29-72
CONTRACTOR APPROVAL		DATE

NEXT ASSY	USED ON
3436-D-2172	

APPLICATION

CODE IDENT 00615 | DWG NO. PL3436-D-2179 | REV A

CONTRACT NO. NAS 5-11396 | SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: Noise Source Switching Helios Radiometer Experiment 5C PC 725

PL 3436-D-2179

REV A

Sh 2 Dwg

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			WM 223	Welded Module	WTA
2	1			WM 222	Welded Module	WTA
3	1			422-12	Relay K1 (Screen per Note 8, PPL-11 Appendix C, Table 06)	MIL-R-5757/71
4	2			TX2N2222A	Transistor, NPN, Q3, Q4	MIL-S-19500/ 255 E
5	1			TX2N2369A	Transistor, NPN, Q2	MIL-S-19500/ 317 D
6	2			TX1N645	Diode, CR2, CR3	MIL-S-19500/ 240 C
7	2			CSR13E107KS	Capacitor, 100uf 20v, 10%, C5, C10	MIL-C-39003/1
8	3			RCR07G104JS	Resistor, 100K 1/4w 5%, R5, R15, R13	MIL-R-39008/1
9	2			RCR07G243JS	Resistor, 24K 1/4w 5%, R14, R16	MIL-R-39008/1
10	1			RCR07G513JS	Resistor, 51K 1/4w 5%, R12	MIL-R-39008/1
11	Ref					
12	18					
13	1					
14	Ref					

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title: Noise Source Switching
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2179

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
WM 223	WM 223	Noise Source Switching	W-2	.01		70	F	F		
WM 222	WM 222	" " "	W-2	.01		70	F	F		
K 1	422-12	Relay	Mil-R-5757/71	.06		70	F	F		
Q3	TX2N2222A	Transistor	Mil-S-19500/255E	.01	2%	70	F	F		
Q4	"	"	"	.01	2%	70	F	F		
Q2	TX2N2369A	Transistor	Mil-S-19500/317D	.01	2%	70	F	F		
CR2	TX1N645	Diode	Mil-S-19500/240C	.01	1%	70	F	F		
CR3	"	"	"	.01	1%	70	F	F		
C5	CSR13E107KS	Capacitor	Mil-C-39003/1	.001	60%	70	F	F		
C10	"	"	"	.001	60%	70	F	F		
R5	RCR07G104JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		
R15	"	"	"	.001	1%	70	F	F		
R13	"	"	"	.001	10%	70	F	F		
R14	RCR07G243JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		
R16	"	"	"	.001	10%	70	F	F		
R12	RCR07G513JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
		3-28-72	[illegible]
A	COMPLETELY REVISED	1-30-73	HP
B	Revised per DCN 3436-D-2167	9/24/73	HP
C	Revised per DCN PL3436-D-2167C2		

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							
C	C																																							

NEXT ASSY	USED ON
3436-D-2171	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	JNH	3-27-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	9-29-72

CONTRACTOR APPROVAL — DATE

TITLE: MIXER, HELIOS RADIOMETER EXPERIMENT 5C (PC721)

CODE IDENT	DWG NO.	REV
00615	3436-D-2167	C

CONTRACT NO. NAS 5-11396 — SHEET 1 OF 2

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: MIXER, HELIOS RADIOMETER EXPERIMENT 5C (PC721)

PL 3436-D-2167 — REV C

Symbols
T – TOTAL QUANTITY OF RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Sh 2 Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			MS90537-14	Coil RF, 1.2 UH, L1	LT K242 MIL-C-15305
2	1			MS90537-18	Coil RF, 2.7 UH, L2	
3	1			3436-D-2170-9	Torriod Assembly	
4	1			CKR06BX122KS	Capacitor, 1200 pf @ 200 V, 10%, C4	MIL-C-39014/2
5	1			CKR05BX471KS	Capacitor, 470 pf @ 200 V, 10%, C43	MIL-C-39014/1
6	2			CKR05BX KS	Capacitor, (TBD), C24, C49	MIL-C-39014/1
7	1			SM307	Mixer, M1	WTA 22345C
8						
9						
10						
11						
12						
13						
14						Product Components Co.
15						"
16						"
17						

WTA Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Mixer PC 721
Schematic No. 3436-J-2163
Drawing No.& Parts List No. 3436-D-2167

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
L1	MS90537-14	Coil, RF	LT4K242 Mil-C-15305	.054	20%	70	F	PF		
L2	MS90537-18	Coil, RF	LT4K242 Mil-C-15305	.054	20%	70	F	PF		
L3	MS90537-19	Coil, RF	Mil-C-15305	.054	20%	70	PF	F		
C4	CKR06BX122KS	Capacitor	Mil-C-39014/2	.001	3%	70	PF	F		
C43	CKR05BX471KS	"	Mil-C-39014/1	.001	3%	70	PF	F		
C24	CKR05BX KS	"	Mil-C-39014/1	.001	10%	70	PF	F		TBD
C49	"	"	"	.001	10%	70	PF	F		TBD
M1	SM 307	Mixer		.054		70	F	F		
R15	RCR07G510JS	Resistor	Mil-R-39008/1	.001	10%	70	PF	F		

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LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Sheet 1, Item 7, 8	8-22-72	[illegible]
B	Revise per DCN PLWM221B1		

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B																																							

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	NH	8-22-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	8-29-72

CONTRACTOR APPROVAL DATE

NEXT ASSY	USED ON
3436-D-2178	

APPLICATION

TITLE Command Interface-Module
Helios-Radiometer
Experiment 5C

CODE IDENT	DWG NO.	REV
00615	WM 221	B

CONTRACT NO. NAS 5-11396 SHEET 1 OF 2

WTA WASHINGTON TECHNOLOGICAL ASSOCIATES, INC. 979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852 *Subsidiary of Quanta Systems Corporation*	Title Command Interface-Module Helios Radiometer, Experiment 5C	PL WM 221 — B REV
	Symbols T - TOTAL QUANTITY OR RECURRING ITEM B - BULK MATERIAL SC - SOURCE CONTROL DWG SPC - SPECIFICATION CONTROL	Sh 2 Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	9			TX2N2369A	Transistor, NPN - Q17-1, Q17-2	MIL-S-19500/ 317D
2	18			TX2N2607A	Transistor, Q18-1, Q18-2, Q19-1, Q19-2, Q20-1, Q20-2,	
					Q21-1,Q21-2,Q22-1,Q22-2,Q22-3,Q22-4,Q22-5,Q22-6,Q22-7	
3	7			CBD 5135	Resistor, 51K 1/4w 5% - R44-1, R44-2	Allen Bradley
4	7			CBD 1535	Resistor, 15K 1/4w 5% - R43-1, R43-2	Allen Bradley
5	7			CBD 1035	Resistor, 10K, 1/4w 5% - R45-1, R45-2	Allen Bradley
6	14			CBD 1055	Resistor, 1M 1/4w 5% - R46-1, R46-2, R47-1, R47-2	Allen Bradley
7						
8						

FAILURE AND MODE EFFECTS ANALYSIS

Title: Command Interface Module
Schematic No. 3436-J-2163
Drawing No. &
Parts List No. WM221

Quantity	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage Curr, Pwr.	Ambient Temp. °C	Effect of Failure Open	Short	Other
9	TX2N2369A	Transistor	Mil-S-19500/317D	.09	10%	70	F	F	
14	TX2N2607A	Transistor	Mil-S-19500/294A	.14	10%	70	F	F	
7	CBD 5135	Resistor	Allen Bradley	.007	1%	70	F	F	
7	CBD 5135	Resistor	Allen Bradley	.007	3%	70	F	F	
7	CBD 1035	Resistor	Allen Bradley	.007	3%	70	F	F	
14	CBD 1055	Resistor	Allen Bradley	.014	1%	70	F	F	

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
		10-3-72	
A	Added Sheet 3 Items 20 thru 23 and Added -1 to Item 16	2-22-73	
B	Revised per DCN 3436-D-2253-A1	3-7-73	
C	Add C28 to Item 3, R100 to Item 9, 91 ohm to Item 13		

Status of Revision of Each Sheet

1	2	3
A	A	A
B	B	B
C	C	B

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	JH	9-27-72
PROJECT ENGR.		
APPROVED		9-29-72

NEXT ASSY	USED ON
3436-D-2171	

APPLICATION

CONTRACTOR APPROVAL DATE

TITLE
DETECTOR, HELIOS RADIOMETER EXPERIMENT 5C (PC785)

CODE IDENT	DWG NO.	REV
00615	3436-D-2253	C

CONTRACT NO. NAS 5-11396 SHEET 1 OF 3

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: DETECTOR, HELIOS RADIOMETER EXPERIMENT 5C (PC 785)

PL 3436-D-2253

REV C

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh 2
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			3436-C-2170-6	Toroid, 1.8 UH, L6	WTA
2	2			3436-C-2170-5	Toroid, .65 UH, L5, L7	WTA
3	3			CKR05BX KS	Capacitor, (TBD), C53, C25, C26, C28	MIL-C-39014/1
4	1			CKR05BX KS	Capacitor, TBD	
5	3			CKR06BX103KS	Capacitor, .01 UF @ 200 V, 10%, C29, C27, C51	MIL-C-39014/2
6	1			TX2N918	Transistor, Q20	MIL-S-19500/301A
7	1			TX2N2369	Transistor, Q21	MIL-S-19500/317D
8	1			TX1N5711	Diode, CR4	MIL-S-19500/444
9	2			RCR07G JS	Resistor, TBD , R30, R33, R100	MIL-R-39008/1
10	1			RCR07G471JS	Resistor, 470 ohms, 1/4w, 5%, R29	MIL-R-39008/1
11	1			RCR07G182JS	Resistor, 1.8K, 1/4w, 5%, R31	MIL-R-39008/1
12	1			RCR07G183JS	Resistor, 18K, 1/4w, 5%, R93	MIL-R-39008/1
13	1			RCR07G910JS	Resistor, .91 ohm 1/4w, 5%, R92	MIL-R-39008/1
14						
15						
16						
17				CSR13B476KS	Capacitor, C52	MIL-C-39003/1
18				RCR07G331JS	Resistor, R100	MIL-R-39008/1
19						

WTA Job No. 3436-002
Contract NAS5-11395

Failure Mode and Effects Analysis

Title Detector PC 785
Schematic No. 3436-J-2163
Drawing No.&
Parts List No. 3436-D-2253

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
L6	3436-C-2170-6	Toroid	WTA	.05	20%	70	F	F		
L5	3436-C-2170-5	"	WTA	.05	20%	70	F	F		
L7	"	"	"	.05	20%	70	F	F		
C53	CKR05BX KS	Capacitor	Mil-C-39014/1	.001	10%	70	PF	F		TBD
C25	"	"	"	.001	10%	70	PF	F		TBD
C26	"	"	"	.001	10%	70	PF	F		TBD
C28	CKR05BX820KS	Capacitor	Mil-C-39014/1	.001	12%	70	PF	F		
C29	CKR06BX103KS	"	Mil-C-39014/2	.001	10%	70	PF	F		
C27	"	"	Mil-39014/2	.001	10%	70	F	F		
C51	"	"	"	.001	12%	70	F	F		
C52	CSR13B476KS	Capacitor	Mil-C-39003/1	.001	10%	70	PF	F		
Q20	TX2N918	Transistor	Mil-S-19500/301	.01	50%	70	F	F		
Q21	TX2N2369	"	Mil-S-19500/317	.01	50%	70	F	F		
CR4	TX1N5711	Diode	Mil-S-19500/444	.01	2%	70	F	F		
R30	RCR07G101JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		
R33	"	"	"	.001	40%	70	F	F		
R29	RCR07G471JS	"	"	.001	10%	70	F	F		
R31	RCR07G182JS	"	"	.001	10%	70	F	F		
R93	RCR07G183JS	"	"	.001	20%	70	F	F		
R92	RCR07G JS	"	"	.001		70	F	F		TBD
R100	RCR07G331JS	"	"	.001	10%	70	F	PF		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	Added Items 11, 12, and 13. Quantity of Item 8 was 8	11-2-72	[illegible]
B	Added Items 14 thru 25, and added Sheet 3	1-30-73	[illegible]
C	Revised per DCN S/N 3436-D-2172 - C1	3/6/73	[illegible]
D	Revision per DCNPL 3436-D-2171 D1	9/11/73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
A	A																																							
B	B	B																																						
C	C	–																																						
D	–	D																																						

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	[illegible]	9-27-72
PROJECT ENGR.	[illegible]	[illegible]
APPROVED	[illegible]	9-29-72
CONTRACTOR APPROVAL		DATE

NEXT ASSY	USED ON
APPLICATION	

TITLE
MIXER-FILTER-DETECTOR ASSEMBLY
HELIOS RADIOMETER
EXPERIMENT 5C

CODE IDENT	DWG NO.	REV
00615	3436-D-2171	

CONTRACT NO. NAS 5-11396 SHEET 1 OF 3

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WASHINGTON TECHNOLOGICAL ASSOCIATES, INC. 979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852 *Subsidiary of Quanta Systems Corporation*	Title: MIXER-FILTER-DETECTOR ASSEMBLY HELIOS RADIOMETER EXPERIMENT 5C	PL 3436-D-2171	REV
	Symbols T - TOTAL QUANTITY OR RECURRING ITEM B - BULK MATERIAL SC - SOURCE CONTROL DWG SPC - SPECIFICATION CONTROL		Sh Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			F-14072A	Filter, FL1	WTA 20614D

WTA Job No. 3436-002
Contract NAS5-11395

Failure Mode and Effects Analysis

Title Mixer-Filter Detector
Schematic No. 3436-J-2163
Drawing No. &
Parts List No. 3436-D-2171

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp.°C.	Effect of Failure Open	Short	Other	Remarks/Notes
FL 1	F-14072A	Filter	WTA 20614D	.062		70	F	F		

LTR	DESCRIPTION OF REVISION	DATE	APPROVED
A	COMPLETELY REVISED	9-27-72	[illegible]
B	Added Items 27 and 28	10-5-72	R.D.
C	Revised per DCN PL3436-D-2166-B2	11-13-72	R.D.
D	Delete R4 and R26 from Item 21 - Add R26 to Item 12	3-7-73	[illegible]

Status of Revision of Each Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
B	A	B																																						
C	C	C																																						
D	D	D																																						

NEXT ASSY	USED ON
3436-D-2172	

APPLICATION

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
Rockville, Maryland
quanta systems corporation

	NAME	DATE
PREPARED BY	[illegible]	9-25-72
PROJECT ENGR.	-	[illegible]
APPROVED	[illegible]	9-27-72

CONTRACTOR APPROVAL | DATE

TITLE
NOISE SOURCE ASSEMBLY, PC722
HELIOS RADIOMETER
EXPERIMENT 5C

CODE IDENT	DWG NO.	REV
00615	3436-D-2166	D

CONTRACT NO. NAS 5-11396 | SHEET 1 OF 3

ORIGINAL PAGE IS OF POOR QUALITY

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: NOISE SOURCE ASSEMBLY, PC722
HELIOS RADIOMETER
EXPERIMENT 5C

3436-D-2166

REV D

Symbols
T – TOTAL QUANTITY OR RECURRING ITEM
B – BULK MATERIAL
SC – SOURCE CONTROL DWG
SPC – SPECIFICATION CONTROL

Sh 2
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
1	1			MC1552GH2	Integrated Circuit, A1	WTA 20610 G
2	1			SH-79	Transformer, T1	WTA 22344
3	2			TX2N4857	Transistor (FET), Q5, Q9	MIL-S-19500/431
4	2			TX2N2369A	Transistor, Q6, Q7	MIL-S-19500/317D
5	1			TX2N3251A	Transistor, Q[illegible]	MIL-S-19500/323A
6	1			SD20TX	Diode, Noise, CR1	WTA 22346A
7	2			TX1N645	Diode, CR4, CR19	MIL-S-19500/240C
8	1			TX1N752A	Diode, Zener CR5	MIL-S-19500/127E
9	11			CKR06BX105KS	Capacitor, 1 UF @ 50V, 10%, C1 thru C4, C12 thru C17 C23	MIL-C-39014/2
10	6			CKR05BX152KS	Capacitor, 1500pf @ 100V, 10%, C18 thru C22, C6	MIL-C-39014/1
11	2			CSR13G225KS	Capacitor, 2.2 UF @ 20 V, 10%, C24, C25	MIL-C-39003/1
12	5			RCR07G510JS	Resistor, 51 ohm, 1/4w, 5%, R1, R3, R26, R19, R60	MIL-R-39008/1
13	7			RCR07G102JS	Resistor, 1K, 1/4w, 5%, R2, R48 thru R52, and R59	MIL-R-39008/1
14	1			RCR07G JS	Resistor, (2 K, TBD), 1/4w, 5%, R10	MIL-R-39008/1
15	2			RCR07G103JS	Resistor, 10K, 1/4w, 5%, R11, R24	MIL-R-39008/1
16	1			RCR07G512JS	Resistor, 5.1K, 1/4w, 5%, R21	MIL-R-39008/1
17	1			RCR07G101JS	Resistor, 100 ohm, 1/4w, 5%, R54	MIL-R-39008/1
18	1			RCR07G	Resistor (TBD 3K), 1/4w, 5%, R25	MIL-R-39008/1
19	1			RCR07G222JS	Resistor, 2.2K, 1/4w, 5%, R20	MIL-R-39008/1

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.
979 ROLLINS AVENUE, ROCKVILLE, MARYLAND 20852
Subsidiary of Quanta Systems Corporation

Title: NOISE SOURCE ASSEMBLY
PC722 HELIOS RADIOMETER
EXPERIMENT 5C

PL 3436-D-2166

D
REV

Symbols
T - TOTAL QUANTITY OR RECURRING ITEM
B - BULK MATERIAL
SC - SOURCE CONTROL DWG
SPC - SPECIFICATION CONTROL

Sh 3
Dwg

Find No.	Qty Req'd	Sym	Code Ident	Part or Identifying No.	Description	Spec or Note
20	2			RCR07G511JS	Resistor, 510 ohm, 1/4w, 5%, R17, R18	MIL-R-39008/1
21	1			RCR07G JS	Resistor, (TBD), 1/4w, 5%, , R53,	MIL-R-39008/1
22	2			RCR07G JS	Resistor, (TBD), 1/4w, 5%, R58, R56	MIL-R-39008/1
23	1				Thermistor, R57, TBD	
24						
25						
26						
27						
28						
29						

W.A Job No. 3436-032
Contract NAS5-11396

Failure Mode and Effects Analysis

Title: Noise Source PC 722
Schematic No. 3436-J-2163
Drawing No.& Parts List No. 3436-D-2166 Page 1 of 3

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
R17	RCR07G511JS	Resistor	Mil-R-39008/1	.001	5%	70	F	F		
R18	"	"	"	.001	5%	70	F	F		
R4	RCR07G JS	Resistor	Mil-R-39008/1	.001	1%	70	F	F		TBD
R53	"	"	"	.001	10%	70	F	PF		TBD
R26	"	"	"	.001	10%	70	F	F		TBD
R58	RCR07G JS	Resistor	Mil-R-39008/1	.001	5%	70	F	F		TBD
R56	"	"	"	.001	10%	70	F	F		TBD
R57		Thermistor			10%	70	F	F		TBD
A1	MC1552GH2	Integrated Circuit	WTA 20610G	.08		70	F	F		
T1	SH 79	Transformer	WTA 22344	.05		70	F	F		
Q5	TX2N4857	Transistor	Mil-S-19500/431	.01	10%	70	F	F		
Q9	"	"	"	.01	10%	70	F	F		
Q6	TX2N2369A	Transistor	Mil-19500/317D	.01	10%	70	F	F		
Q7	"	"	"	.01	10%	70	F	F		
Q8	TX2N3251A	Transistor	Mil-S-19500/323A	.01	10%	70	F	F		
CR 1	SD20TX	Diode, Noise	WTA 22346A	.01	50%	70	F	F		
CR4	TX1N645	Diode	Mil-S-19500/240C	.01	10%	70	F	F		
CR19	"	"	"	.01	10%	70	F	F		
CR5	TX1N752A	Diode	Mil-S-19500/127E	.01	10%	70	F	F		
C 1	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	25%	70	PF	F		
C 2	"	"	"	.001	25%	70	PF	F		

W. L.A. Job No. 3436-002
Contract NAS5-11396

Failure Mode and Effects Analysis

Title Noise Source PC 722
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2166 Page 2 of 3

E=Estimate

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr, Pwr.	Ambient Temp. °C.	Effect of Failure Open	Effect of Failure Short	Effect of Failure Other	Remarks/Notes
C 3	CKR06BX105KS	Capacitor	Mil-C-39014/2	.001	10%	70	F	F		
C 4	"	"	"	.001	10%	70	F	F		
C12	"	"	"	.001	20%	70	F	F		
C13	"	"	"	.001	10%	70	F	F		
C14	"	"	"	.001	25%	70	PF	F		
C15	"	"	"	.001	5%	70	PF	F		
C16	"	"	"	.001	25%	70	PF	F		
C17	"	"	"	.001	10%	70	F	F		
C23	"	"	"	.001	25%	70	PF	F		
C18	CKR05BX152KS	Capacitor	Mil-C-39014/1	.001	1%	70	PF	PF		
C19	"	"	"	.001	1%	70	PF	PF		
C20	"	"	"	.001	1%	70	PF	PF		
C21	"	"	"	.001	1%	70	PF	PF		
C22	"	"	"	.001	2%	70	PF	PF		
C6	"	"	"	.001	1%	70	PF	PF		
C24	CSR13G225KS	Capacitor	Mil-C-39003/1	.001	25%	70	PF	F		
C25	"	"	"	.001	25%	70	PF	F		
R1	RCR07G510JS	Resistor	Mil-R-39008/1	.001	1%	70	F	PF		
R3	"	"	"	.001	1%	70	F	PF		
R4	"	"	"	.001	1%	70	F	F		
R19	"	"	"	.001	1%	70	F	PF		
R60	"	"	"	.001	3%	70	F	PF		
R2	RCR07G102JS	Resistor	Mil-R-39008/1	.001	30%	70	F	F		
R48	"	"	"	.001	1%	70	PF	PF		
R49	"	"	"	.001	1%	70	PF	PF		
R50	"	"	"	.001	1%	70	PF	PF		

W [illegible] Job No. 3436-002
Contract NAS5-11398

Failure Mode and Effects Analysis

E=Estimate

Title: Noise Source PC 722
Schematic No. 3436-J-2163
Drawing No. & Parts List No. 3436-D-2166 Page 3 of 3

Reference Designation	Part No.	Description	Specification	Rel. Level Failure Rate %/1000 Hours	Derated to % of Rated Voltage, Curr. Pwr.	Ambient Temp. °C.	Effect of Failure Open	Short	Other	Remarks/Notes
R51	RCR07G102JS	Resistor	Mil-R-39008/1	.001	1%	70	PF	PF		
R52	"	"	"	.001	1%	70	PF	PF		
R59	"	"	"	.001	0 %	70	F	F		
R10	RCR07G JS	Resistor	Mil-R-39008/1	.001	10%	70	F	PF		TBD
R11	RCR07G103JS	Resistor	Mil-R-39008/1	.001	2%	70	F	F		
R24	"	"	"	.001	5%	70	F	F		
R21	RCR07G512JS	Resistor	Mil-R-39008/1	.001	2%	70	F	F		
R54	RCR07G101JS	Resistor	Mil-R-39008/1	.001	2%	70	F	F		
R25	RCR07G JS	Resistor	Mil-R-39008/1	.001	5%	70	F	F		TBD
R20	RCR07G222JS	Resistor	Mil-R-39008/1	.001	10%	70	F	F		

APPENDICES

A. Specification

B. Reliability Analysis

C. Test Plan

D. Calibration

APPENDIX A

1 GSFC Procurement Specification for Helios Dual Swept Frequency Radiometer System

2 Helios Project Experiment Data and Command Handling Requirements.

3 GSFC Specification for Reliability and Quality Assurance Provisions for Helios Project Instrument.

APPENDIX A 1

GSFC Procurement Specification for Helios Dual Swept Frequency Radiometer System

PART V - A

PC# 693-32818
S-693-P-2
29 July 1970

GSFC PROCUREMENT SPECIFICATION

FOR

HELIOS DUAL SWEPT FREQUENCY RADIOMETER SYSTEM

PREPARED BY

RADIO ASTRONOMY BRANCH
LABORATORY FOR EXTRATERRESTRIAL PHYSICS
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

PC# 693-32818
S-693-P-2
29 July 1970

GSFC PROCUREMENT SPECIFICATION

FOR

HELIOS SWEPT FREQUENCY RADIOMETER SYSTEM

PREPARED BY: Radio Astronomy Branch
Laboratory for Extraterrestrial Physics

APPROVED BY:

R. G. Stone, Head
Radio Astronomy Branch

6 AUG 70
Date

Gilbert Ousley
Helios, Project
Manager

8 Aug 70
Date

George F. Pieper
Director
Space and Earth Science

9/11/70
Date

2.1 SPECIFICATIONS

MIL-I-618D	Interference control requirements, aircraft equipment
GSFC 5250-P-1	Specification for Contractor prepared monthly, periodic, and final project reports
GSFC X623-63-147 or equivalent	Specification drawings, engineering and associated lists
Helios Experiments Design & Test Specifications	Attachment A
MSFC-SPEC-279	Electromagnetic compatibility June 1, 1964

2.2 STANDARDS

MSFC STD-154	Printed circuit design and constructi
MSFC STD-156	Riviting, fabrication, and inspection standard for
MSFC STD-270A	Component lead and interconnection materials for welded electronic modules, specification for
MSFC STD-271	Fabrication of welded electronic modules, standard for

2.3 PUBLICATIONS

GSFC-PPL-11	Preferred parts list
FED-STD-102	Preservation packaging, and packing levels
FED-STD-123	Marking for domestic shipment
MIL-HDBK-217	Reliability stress and failure rate path for electronic equipment 8 August

PC#693-32818

GSFC S-312-P-1	GSFC Specification for Contractor Malfunction Reporting, March 24, 197
GSFC S-702-P-1	Specification for reliability and quality assurance provisions for Helios Project Instruments August 7, 1970
Helios Project	Experiment Data and Command Handling Requirements Attachment B

3.0 SCOPE

This specification describes in detail, the implementation of an experiment to study the radio spectrum between 50 kHz and 3 MHz. The experiment is a dual sweeping receiver designed specifically for radio studies of the sun and the local region of our galaxy.

4.0 APPLICABLE DOCUMENTS

The specifications, standards, drawings and publications of current issue shall apply as detailed in this specification. In the event of conflict, the detailed provisions of this specification shall govern.

5.0 REQUIREMENTS

One proto system, one proto spare system, one engineering test unit system, one flight system and one flight back-up are required. This specification and Helios environmental test specifications will apply to all units.

5.0.1 The Environmental Test Specifications for Helios flight and spare subsystems is under separate cover and attached to this specification.

5.0.2 The Radio Astronomy Experiment for Helios shall be designed and constructed to satisfy all of these requirements.

6.0 GENERAL

Materials and processes used during manufacture of items, covered herein shall be of high quality, suitable for the purpose,

and conform to the applicable Government specifications as applied to Materials, Metals, Component Parts, Soldering Techniques and Workmanship.

7.0 MECHANICAL REQUIREMENTS

7.1 CONFIGURATION

The dual swept radiometer which includes the radiometers, internal noise source, and crystal controlled oscillators shall be contained in one package. The package dimensions, excluding possible mounting brackets, shall not exceed $2\frac{1}{2}$ x 5 x 7 inches. The radiometer preamps will be separate and located near the experiment antennas. ~~The preamp dimensions shall be 1 x 2 x 4 inches~~. Each preamp will be mounted in a package supplied by another experiment and located near an antenna. The noise/ calibrate switching will be performed by the spacecraft programmer The vendor is required to supply the preamp and attenuator switching circuit as a P.C. plug-in module not to exceed one inch in height.

Deleted See Addendum #1, Jul 29, 1970 For Change

7.2 WEIGHT

~~The total weight of a system including potting and frames will not exceed 1.7 kilograms. A design goal of 1.2 kg maximum shall be used~~.

Deleted See Change As outlined In Addendum #1, Jul. 29, 70

7.3 PACKAGING

The unit packaging shall employ the latest state-of-the-art techniques approved by NASA GSFC Q.A as applied to electrical design and assembly of circuit boards, integrated circuits, hybrid networks, and individual component parts. All component parts subject to vibration amplification due to mounting, shall be bonded to a rigid structure. The unit will then be encapsulated in a low density foam.

7.4 MARKING

The marking must not damage the unit or affect its functional use.

7.5 CONNECTORS

Flight approved Cannon "DM" non-magnetic connectors are required for electrical interface. Actual type and number will

depend upon wire type and spacecraft requirements.

The connectors shall satisfy the electrical interface specifications, and be mounted in accordance with the mechanical interface document.

7.6 FINISHES

Refer to the mechanical interface document for external surface finish.

8.0 TEMPERATURE MONITORS

Provision shall be made at the noise source and both preamps for mounting a thermistor to monitor the internal temperature. An analog output line from each thermistor must be provided.

9.0 ELECTRICAL REQUIREMENTS

Figure 1 is a block diagram of the Helios Mission Swept Frequency Radiometer experiment.

9.1 The System Assembly consists of two swept radiometers, a noise source for calibration, a redundancy selection circuit for independent control of each radiometer, two crystal controlled oscillators and two single ended preamplifiers.

9.1.1 The design concept for the Helios Mission is the operation of the burst-radiometer to sweep in one of several modes, so that the outputs can be read out in the telemetry format. The operating modes of the radiometer will be controlled by the spacecraft programmer. The oscillator for each radiometer must be able to switch to any sequence when the appropriate four (4) binary bits are applied. Each radiometer will be controlled by four lines from the programmer and must be capable of staying on one of the 16 frequencies if programmed.

The calibration of the radiometer will be accomplished when the spacecraft programmer provides a cal/data command to the noise source. The noise source will have four (4) calibration levels, ~~one for each 30db of dynamic range.~~

Each radiometer must be fully redundant with a pair or identical channels designated A & B. In order to select channel A or B, the proper signals must be sent to the redundancy

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control circuitry. The redundancy circuitry must be fail-safe, that is, either A or B must be powered if a failure occurs in the switching device.

9.2 FREQUENCY COVERAGE

The frequency band swept by each radiometer is 50 kHz through 3 MHz. Table A is a list of the center frequencies of each of the 16 channels. The table indicates preferred frequencies; however, some deviation from the actual listed frequencies may occur.

9.3 INPUT IMPEDANCE

Each Radiometer Preamplifier system shall have a balanced input. The balanced input minimum parallel resistance and maximum parallel capacitance in the frequency range 50 kHz to 3 MHz shall be greater than 100 kilohms and less than 8 pf, respectively. Phase and amplitude control of each RF amplifier comprising the balanced input circuitry must be maintained in order to achieve a high common mode rejection ratio. Phase shifts from the inputs of a pair of pre-amps to the input to the radiometer low pass filter shall be equal to within 3 degrees at each operating frequency in the range of 50 kHz to 3 MHz. The tangential sensitivity of the dual radiometer system at the balanced input shall be equal to or greater than -100 dbm. The series equivalent impedances (both resistance and reactance) to ground of the two balanced input ports shall equal to within ±5%.

9.4 PREAMPLIFIER GAIN

The gain of each member of a pair of matched preamplifiers, measured at the input to the low pass filter for signals in the middle of each dynamic range shall be equal, to within ±0.3 db at each operating frequency up to 3 MHz.

9.5 CRYSTAL FILTER BANDWIDTH

Each radiometer shall employ a buffered crystal IF filter. The Half Power Bandwidth of the crystal filter shall be 10 kHz for channels A and B. The center frequency of each crystal filter shall be 21.4 MHz. The crystal filters shall have a 2.3 to 1 or better form factor (3 to 60 db bandwidths). Spurious frequency response shall be attenuated to -60db. Ripple, as

applicable, shall be not greater than 0.3b. Spurious frequency generation shall not occur if the crystal filters are excessively overloaded by large signals.

9.6 CRYSTAL CONTROLLED OSCILLATOR

The swept frequency band of each radiometer is tuned by its local oscillator. The crystal controlled L.O. frequency shall always be above the crystal filter frequency. The L.O. is frequency-stepped by applying a 4 bit finary signal to the oscillator inputs. The spacecraft programmer will control the sweeping action and mode selection of the dual Radiometer System. A monitor shall produce a signal for the TM system to indicate which L.O. frequency is operating.

9.6.1 L.O. Compensation

See Change as outlined in Addendum #1

~~The frequency of the L.O. as determined by the spacecraft programmer, must be repeatable within ±3 percent of the filter bandwidth.~~ Because of the narrow bandwidth requirements of the Radiometer System, temperature-stable components for the L.O. must be selected and all temperature compensating devices selected with caution. Frequency dwell time will be compatible with spacecraft telemetry system as prescribed by the encoding system.

9.7 DETECTORS

The detector shall have a dynamic range of 35 to 40 db. The Radiometer gain shall be set so that an input level corresponding to cosmic noise in each channel corresponds to about 2.0 volts of output on the 0-30db section of the automatic dynamic range curve. The detectors output should be limited to 0.0 to 4.8 volts and must not exceed under any circumstances -0.25 to +5.0 volts. The magnitude of the dynamic range slope shall be identical in all the dynamic ranges. ~~The dynamic range characteristics shall follow a straight line of db in vs. VDC out within ±3db for voltages above 0.8 VDC.~~

See Changes outlined in Addendum #1

NOTE: All channels shall have similar dynamic range characteristics.

9.7.1 Automatic Dynamic Range Operation

Deleted #3 ???

An automatic dynamic range selector shall be provided to choose either the 30db, 60db, 90db, or 120db dynamic range for the unit. The normal mode of operation shall be 30db of input range translated into a DC output range of 0.0 to 4.8 volts. When a burst is received whose range is greater than can be handled with

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this dynamic range, the range selector shall switch to the 60db, 90db, or 120db range. Two automatic range flags shall be provided for range identification. These shall change within 5 milliseconds, ± 1 millisecond after the incoming signal exceeds the criteria for the range being used.

9.7.2 Post Detection Time Constant

The post detection time constant for radiometer A and B shall be 10 ~~milliseconds, ± 1 milli~~second. THRU 100 milliseconds

See mod #3

10.0 INTERNAL NOISE SOURCE

For calibration, the dual Radiometer System shall contain an internal noise source. This noise source, on command from the spacecraft programmer, shall sequentially generate four noise levels above cosmic noise. The cosmic noise reference temperature will be about 3×10^7 $^{\circ}K$ at 1.0 MHz. The spacecraft programmer will supply a calibrate/data command and during this period the system shall supply four (4) calibration noise levels to the preamplifiers at the antenna stations. The radiometer will be swept through its sixteen (16) frequencies at each consecutive noise level. The noise source shall have long and short term stability of ± 0.5 db and shall be shaped to calibrate each range of every frequency somewhere between 1.5 and 4.0 D.C. volts output. The calibration output voltage shall be unique for each of the 16 frequencies as a secondary check on the proper operating frequency of the L.O.

10.1 CALIBRATION

Calibration data for each radiometer system shall be delivered with the radiometer. These data shall demonstrate the proper functioning of the radiometer over its dynamic range and its operating temperature range. Format for these data will be arranged with the NASA Technical Representative.

Data shall be taken at 3db steps throughout the dynamic range of the radiometer.

10.2 RADIOMETER STABILITY

The radiometers shall have a stability and repeatability corresponding to ± 0.1 db of input signal for any operating configuration within the specification limits. This shall apply to output voltages of 0.8 to 4.8 VDC.

11.0 PROGRAMMERS

The dual Radiometer System shall be controlled by the spacecraft programmer contained in the experiment 5 data processing unit. The spacecraft programmer under the control of the various spacecraft encoder signals shall provide the necessary voltages for L.O. functions; internal calibration, the mode change commands, and other timing functions for the successful performance of the dual Radiometer System.

12.0 POWER

The power supplied to the Helios Radiometer is ± 6 VDC ± 1 percent for the main power and +12 VDC for the redundancy circuitry. Maximum power consumption for each radiometer shall not exceed the values given below:

+12 V at 10 ma = 120 ~~125~~ 105

+ 6 V at 175 ma

- 6 V at 125 ma

13.0 INPUT/OUTPUT SIGNAL CONNECTOR

An input/output connector from the experimental package is required for electrical interface. This connector is a flight approved Cannon type. Table 3 shows a probable connector type and typical pin designations.

13.1 OUTPUT LINES T/M

The analog outputs from the dual Radiometer System shall be in the range of 0 to 5V and have an output resistance of less than 10 K ohms. The dynamic range flags shall have a binary output of either 0 or 4.0volts to indicate range 1,2, 3, or 4. The output impedance of these lines shall be capable of providing 0-4 volts across a 10K load.

14.0 DESIGN PRECAUTIONS

The following precautions shall be observed in the design and fabrication of the Helios Dual Swept Frequency Radiometer System.

14.1 Special attention shall be given to the grounding of all circuits and internal sub-units. Due to the essential nature of ground connections, they will be reduandant. Power, signal and chassis grounds shall be isolated.

14.1.1 Because of the sensitivity in the radio frequency range of the experiment, all sources of RFI within this experiment both radiated and conducted, shall fall below the detection level of this system. Furthermore, adequate techniques shall be employed to prevent the introduction of RFI into the experiment by the lines used for electrical interface.

14.1.2 Reliability of operation is of primary importance in the design and fabrication of the system.

14.1.3 Because of magnetic experiments on Helios, the magnetic cleanliness specifications should be considered in choosing components and layout.

15.0 ENVIRONMENTAL QUALIFICATIONS

As determined by the applicable specifications listed in 2.1, the flight units and the flight back-up units shall meet

all environmental qualifications, through the range of conditions specified.

15.1.0 The units shall be operationally temperature tested from -20°C to +70°C. The system shall be calibrated over a temperature range of -10°C to +50°C with no degradation in performance. A temperature change of 10°C, in the range -20°C to +40°C, shall not cause a change of receiver output voltage greater than that corresponding to a 0.5db change in input signal. The aforementioned temperature stability of 0.05db/°C shall specifically apply to that part of the range response curve corresponding to output voltages of 1.0 to 3.0 volts.

16.0 GROUND SUPPORT EQUIPMENT

Two Ground Support Equipments will be supplied. Each will contain a stable noise source for experiment calibration in addition to meeting the following requirements.

16.1.0 The GSE shall supply the proper interface connector, power voltages and programming pulses, pulse levels, and all signals for operation of the radiometer. The GSE will in effect replace the spacecraft for bench checkout of the dual Radiometer System.

16.1.1 The GSE internal programmer must be designed to duplicate in detail the radiometer inputs supplied by the spacecraft.

16.1.2 A dummy antenna shall be provided for testing and calibration of the experiment. GSFC will furnish the physical length of the dipole antenna and its base capacitance when the S/C antenna design is firm.

16.1.3 The GSE noise source shall be calibrated and the data supplied with the delivered unit. The GSE noise source shall have short and long term stability of $\pm.05$ db, and sufficient power to calibrate the radiometer over its 120 db dynamic range. The noise source output shall be variable in 1 db steps over the dynamic range.

16.1.4 Calibration

This unit, in conjunction with the automatic calibration equipment at the NASA integration facility, will be used for final calibration of the system.

See Change As outlined IN Addendum # 1

16.1.5 Both GSE's shall operate identically on 115V 60 Hz and on 220V 50 Hz. ~~In particular, the noise source level shall not change more than 0.01 db.~~

16.1.6 The GSE shall not generate any RFI detectable by the spacecraft.

17.0 RELIABILITY GOALS

Reliability of operation shall be a primary design parameter and shall be given at least equal emphasis with all other design objectives.

The reliability goals for the unit shall be as follows:

(i) Probability of complete failure during a mission of 10,000 hours operating time less than 0.04 (confidence level 60 percent)

(ii) Probability of complete success (i.e. no reduction in performance for at least one of the two radiometers A & B.) during a mission of 10,000 hours operating time greater than 0.8 (confidence level 60 percent).

Both of these figures refer to operation in the space environment.

18.0 SAMPLING, INSPECTION, AND TEST PROCEDURES

18.1 QUALITY ASSURANCE AND RELIABILITY.

The Contractor shall conform to GSFC specification S-702-P-1A. Which contains Helios Project requirements for reliability, quality assurance, malfunction reporting, preferred parts, and configuration management.

18.1.1 Quality Parts and Materials.

The contractor shall implement a program covering selection, specification, and qualification for all items to be used in the system which are not government furnished.

Selection of parts shall be on the basis of "space environment" proven qualifications of each part or material for its application. The term "space environment" implies that the component has been successfully employed on spacecraft in orbit or has been qualified via environmental tests for spacecraft use. Effort should be made to choose items already qualified to pertinent specifications and to minimize number of styles of a generic type. When selecting item previously qualified, the contractor shall devote particular attention to accuracy of data, applicability of bases of qualification, and adequacy of

specifications. Needed additional qualification testing, if any, may then be defined. All parts specifications to be prepared by the contractor for procurement of those parts shall be subject to critical review and approval by GSFC. For parts already in stock that the contractor intends to use their specifications and acceptance records shall be subject to review and approval by GSFC. The review will be completed by GSFC within 10 working days following receipt of the specifications and acceptance records. Wherever possible, parts shall be selected from

) GSFC-PPL-11, July 70, Preferred Parts List

All part ratings shall be derated for design use as necessary to achieve, in conjunction with simplified design and redundancy where necessary, the specified reliability for the unit.

The reliability analysis required as a part of the final report shall be based on MIL-HDBK-217, 8 Aug 62, "Reliability Stress and Failure Rate Data for Electronic Equipment".

18.1.2 Inspection and Acceptance.

All work performed by the contractor will be subject to continuing review and approval of the GSFC Project Engineer, or his representative(s) at all times (within the including period of performance) and places. In the event of a dispute or conflict between the contractor and GSFC representative(s), the issue will be referred to the NASA Project Engineer. His decision will be final.

In addition to final inspection and acceptance, various phases of fabrication and packaging will be monitored. Techniques will be subject to review and approval by the appropriat GSFC representative(s). At critical points during fabrication and testing, workmanship and procedures may be subject to inspection and acceptance.

All work completed and submitted for final inspection and acceptance under this contract will be inspected and accepted for NASA by GSFC Code 693 technical representatives as designated by the Contract Officer. The unit will be accepted only after they have satisfactorily demonstrated conformity with applicable specifications and tests, and are, in the judgement of the inspector, operational.

Final inspection and acceptance will take place at the GSFC.

18.1.3 Failure Reporting System and Reports.

All failures detected during acceptance testing shall be reported on GSFC Malfunction Report, Form GSFC 4-2 (7/64), as required by GSFC Specification S-312-P-1

Reproduce 2 copies of Copy 1 of the Malfunction Report and distribute as follows:

a. Copies 1 and 2 to Quality Engineering Branch Code 312.
b. A reproduced copy to Helios Project Office, Code 702.
c. A reproduced copy to the Technical Officer, Code 693.

In addition, the malfunction shall be reported by phone no later than one-half (1/2) working days after part failure detection. The telephone call to the designated cognizant GSFC representative shall cite part failed, specific test under way at time of failure detection, and any available information as to circumstances and/or probable cause, if known.

A failure analysis shall be performed by the contractor to assign definite cause of part failure (e.g. bad component part in a submodule, bad weld, failure due to vibration, etc.). This analysis should take place as soon as possible and in no event later than the delivery date of the final report, since it may be of assistance to the contractor. One purpose of this failure analysis system and its reporting is to detect faults of a recurring nature in the fabrication and inspection system, such as missed welds, so that appropriate remedial action may be taken at the earliest possible time to prevent the occurrence of additional faults of the same type. Care should be taken in analyzing a failure to prevent additional damage to the rest of the submodule or module, to prevent masking of the true fault, and thus enable an accurate analysis. No part or component which fails shall be thrown away or destroyed, but shall be delivered to GSFC.

When the Malfunction Report has been completed, reproduce 2 copies of Copy 4 and distribute as follows:

a. Copies 4 and 5 to Quality Engineering Branch, Code 312
b. A copy to Helios Project Office, Code 702
c. A copy to the Technical Officer, Code 693.

Failure Analysis Reports generated by the supplier shall reference the serial number affixed to the Malfunction Report.

The following changes in the instructions for completion of the Malfunction Report shall apply for supplier use:

(1) Project Code - Helio in Block 3.
(2) Subsystem designation in Block 5 - Radiometer.

The use of contractor designed forms is allowed for internal contractor record keeping, butthe GSFC Form 4-2 must be submitted to NASA.

18.2 TEST PROGRAM

The contractor shall fully test each unit to insure full compliance with all electrical and mechanical requirements of the specifications. In addition, electrical tests shall be performed over the operating temperature range. The unit then shall be delivered to GSFC where it will be subjected to detailed electrical, and integration tests. It will be returned to the contractor within 90 days for plotting, and after it is returned to GSFC, it will be subjected to vibration tests. Final acceptance will be made thereafter.

All measurements shall be made with instruments which have had their accuracy verified periodically against standards traceable to the National Bureau of Standards.

Data shall be provided to GSFC as specified in paragraph 18.5 of this specification.

The contractor shall be responsible for electricall qualifying the unit over the full temperature range. Th testing shall be performed at the contractor's facility. In- spection of all phases of the actual testing can be expe d as a normal part of monitoring the contract by cognizant personnel of GSFC.

Throughout all inspection and tests the contractor shall maintain a separate log of each individual submodule and system as a means of documenting the history of that item. Each log shall identify the item by submodule type and serial number of system and serial number. Chronological order shall be maintained, accounting for idle periods of time and movements. Entries shall be complete, clear, and include (but not be limited to) the following:

a. Date and time of entry.
b. Identity of inspection or test.
c. Environmental conditions.
d. Characteristics being investigated.
e. Parameter measurements (or reference to specific test spec paragraph).
f. Identification of instrumentation used, including serial number and calibration date.
g. Observed failures and failure report referenced.
h. Accumulated operating time (to closest 5 minutes).
i. Operational discrepancies between test results and pertinent test specifications or drawings.
j. Repair and maintenance record.
k. Record of any unusual or questionable occurrences involving the items.
l. Identify of person making entry and time of entry.

Equipment logs shall be available at all times for inspection and review and shall be delivered with the item.

18.2.1 <u>Temperature</u>

18.2.1.1 Storage Temperature. Not required

18.2.1.2 Operational Temperature. The unit shall be tested to demonstrate compliance with paragraph 15.1.0 of this specification.

18.2.2 <u>Vibration</u>

The unit shall be tested as outlined in Attachment A, Helios experiments and test specification.

18.2.2.1 Sinusoidal Vibration. This test shall be conducted by sweeping the applied frequency once through each range specified in Attachment A.

18.2.3 <u>Thermal Vacuum</u>

The unit shall be tested as specified in Attachment A, Helios experiments and test specification.

18.2.4 <u>Radio Frequency Interference</u>

Test shall be performed to prove compliance with all requirements of Attachment A, Helios Experiments and Test Specification.

18.3 TEST EQUIPMENT DESIGN

Design of test equipment for submodule and system checkout. All necessary special test equipment shall be contractor designed and furnished. The test specifications will include details pertaining to the special test equipment necessary for checkout of the submodules and the system as a whole. Since it will be for bench test and checkout, the test equipment should not be elaborate in appearance or design, but should be functional and emphasize simplicity. The proposed test equipment shall be subject to critical review and approval by GSFC. One complete set of test equipment will be required for use by the contractor during the fabrication and test period. Another set or portion thereof may be required for use by GSFC at the time of ETU delivery. Exact functioning and purpose of the individual test sets will be determined by what circuitry the contractor, subject to GSFC approval, includes in the respective submodules.

18.4 PRE-LAUNCH TESTING EQUIPMENT

The contractor shall provide the necessary ground support equipment for pre-launch testing.

18.4.1 Pre-Launch Support Equipment

This will consist of an accurate noise source, the necessary interface connector, CW Balun, and dummy antenna.

18.4.1.1 Interface. The ground support equipment will have provision for monitoring the video output of each channel and all other outputs. Inputs for operation via external power supplies shall be provided. Also any necessary commands for the operation of the unit shall be provided.

18.4.1.2 CW Balun. Provisions are to be included for inserting CW signals from a single-ended unbalanced 50 Ω source to the input of the balanced radiometers. This shall be provided over the entire frequency range with a minimum of insertion loss (less than 3 db).

18.4.1.3 Calibration. Calibration data shall be supplied with delivery of the ground support equipment. The methods used for calibration are to be discussed and approved by the NASA technical director.

18.4.1.4 Sync Pulse and Frame Pulse Generator. The ground support equipment must supply simulated bit clock and frame sync pulses for the proper operation of the dual radiometer unit.

18.5 DOCUMENTATION

The basic philosophy of the data required is that it must be sufficient to summarize the program, document technical advances, fully describe developed equipment, and in particular, to permit fabrication, adjustment, test and operation of developed equipment by any qualified source.

18.5.1 MONTHLY STATUS REPORTS

These reports should be informal in appearance and presentation. They should be comprehensive but concise in nature, and should inform regarding the state of schedule, rate of progress and expenditure, all failures referenced, current problem areas together with remedial action suggested, and problem areas which are anticipated. Urgent problems may be discussed by telephone and these conversations should be referenced in the reports.

18.5.2 INTEGRATION DATA.

Forty-five (45) days after award of contract the following shall be delivered in one (1) reproducible and five (5) copies:

(1) Outline drawings showing overall dimensions, mounting features, connector location and type; and
(2) Interconnection diagrams.

18.5.3 TEST PLAN

A test plan shall be provided in five (5) copies with the first unit delivered. It shall be fully detailed, and shall completely describe both qualification testing and operational testing.

18.5.4 TEST DATA AND PRELIMINARY OPERATION INSTRUCTIONS.

Complete test and calibration data and preliminary operating instructions in five (5) copies shall be provided with each unit delivered. The test data shall be taken prior to delivery on each unit and shall be in accordance with the specification.

18.5.5 ENGINEERING DRAWINGS

Engineering drawings of the last unit shall be provided in five sets, one of which shall be reproducible, within 30 days after delivery of the last hardware item. The drawings shall be class II (i.e., the contractor's drawing standards shall apply) in accordance with GSFC specification X623-63-147 (based on MIL-D-70327). All electrical and mechanical drawings, including complete schematics and parts lists, shall be provided. Any contractor specifications that are referenced shall be supplied also in the same number of copies.

18.5.6 DRAWINGS/CALIBRATION.

Lab type drawings of the ground support equipment and calibration data of the unit shall be delivered one (1) copy of each with delivery of the ground support equipment.

18.5.7 FINAL REPORT

A final report shall be provided in 20 copies within 30 days after delivery of the last hardware item. It shall comply with requirements of GSFC S-250-P1B for type III reports, and shall include but not be limited to:

(1) a summary of the program;
(2) operation of the system;
(3) theory of operation to fully explain the operation of the system (functional block diagrams and schematics shall be provided as required);
(4) maintenance data if applicable;
(5) complete circuit description;
(6) complete set of specifications;
(7) a reliability analysis;
(8) a complete failure analysis;
(9) radiation effects analysis;
(10) complete design information and drawings for any test jigs used in testing the unit;

(11) test procedures;
(12) a complete set of calibration data for each unit delivered, GSE and flight hardware.

18.6 PREPARATION FOR DELIVERY

18.6.1 GENERAL

Equipment prepared for delivery shall be packaged in a manner to ensure delivery without damage. It shall be enclosed by a vapor barrier, which shall contain a desiccant. The humidity state shall be ascertainable without breakage of the vapor seal. The packaging shall also be suitable for storage. The package and equipment shall survive a temperature range (non-operating) of -30°C to +60°C.

18.6.2 SHIPPING INSTRUCTIONS.

The F.O.B. destination shall be Goddard Space Flight Center, Greenbelt, Maryland. Packages shall be marked as follows:

National Aeronautics & Space Administration
Goddard Space Flight Center
Code 693
Greenbelt Maryland 20771
ATTENTION: Richard R. Weber

Helios Electronic Components
HANDLE WITH EXTREME CAUTION

Completed hardware shall be packaged as specified by level C of FED STD-102. A telegram stating date of shipment, name of carrier, waybill number and airline freight number shall be forwarded on shipment to the

National Aeronautics and Space Administration
Goddard Space Flight Center
Code 693
Greenbelt Maryland 20771

19.0 NOTES

19.1 PARTS LISTS

Parts Lists will be submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Code 693
Greenbelt Maryland 20771

ATTENTION: Richard R. Weber

For review prior to commencement of fabrication. If nothing is heard within a 15 working day period approval may be assumed.

TABLE A

STEP	CENTER FREQ. (kHz)
1	26.5
2	50
3	65
4	85
5	115
6	150
7	195
8	255
9	340
10	445
11	585
12	765
13	1,010
14	1,320
15	2,280
16	3,000

TABLE B

CONNECTOR TYPE AND PIN DESIGNATIONS

Connector Type: Cannon DDM36W4P with coax insert type DM53740-1

Pin No.	Type	Function
A1	Coaxial	R. F. Input from Preamp A
A2	Coaxial	R. F. Input from Preamp B
A3	Coaxial	Noise Source Output to Preamp A
A4	Coaxial	Noise Source Output to Preamp B
1	#20 Solid Pin	Noise Source Temperature Output
2	↑	+6 VA
3		+6 VB
4		Spare
5		Noise Source Level Select One - N1
6		Preamp A Chassis and Signal Ground
7		Noise Source Level Select Two - N2
8		Preamp B Chassis and Signal Ground
9		Redundancy Command
10		Cal/Data Command
11		-6 VA
12		-6 VB
13		Interlock
14		Interlock
15		+12V for Thermistors and Redundancy Circuitry
16		+12V for Thermistors and Redundancy Circuitry
17		A0 Control Line for Oscillator A
18		A1 Control Line for Oscillator A
19		A2 Control Line for Oscillator A
20		A3 Control Line for Oscillator A
21		B0 Control Line for Oscillator B
22		B1 Control Line for Oscillator B
23		B2 Control Line for Oscillator B
24		B3 Control Line for Oscillator B
25		+6.0 Volts Power
26		+6.0 Volts Power
27		SRB-A Output
28		SRB-B Output
29		Attenuator Control & Range Flag One
30		Attenuator Control and Range Flag Two
31		Preamp B Temperature Monitor
32		Chassis and Signal Ground
33		Chassis and Signal Ground
34		Preamp A Temperature Monitor
35	↓	-6.0 Volts Power
36	#20 Solid Pin	-6.0 Volts Power

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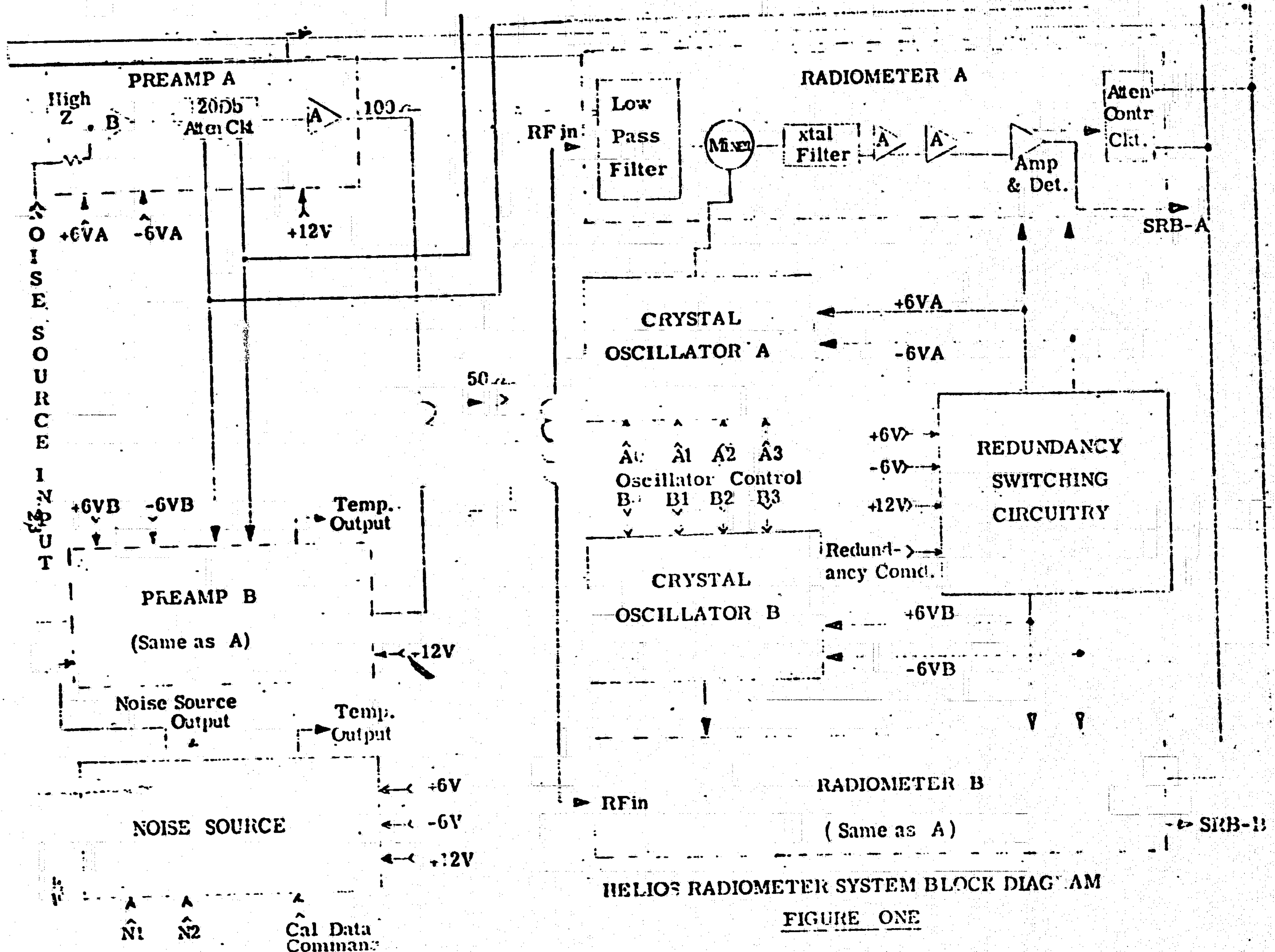

HELIOS RADIOMETER SYSTEM BLOCK DIAGRAM

FIGURE ONE

APPENDIX A 2

Helios Project Experiment Data and Command Handling

Requirement

HELIOS PROJECT EXPERIMENT DATA AND
COMMAND HANDLING REQUIREMENTS

HELIOS PROJECT
EXPERIMENT DATA AND COMMAND
HANDLING REQUIREMENTS

5c Description of Commands and Data for Experiment No. 5c.

5c-1 Description of Commands

5c-1.1 (A) Normal Operation - On command the experiment will step through the frequencies in pairs, e.g. 1-9, 2-10,...8-16. Several samples are taken at each pair.

(B) Radiometer 1 or 2 choice - On command the experiment will switch from radiometer 1 to 2 or from 2 to 1.

(C) Sweep Frequency Operation - On command the experiment will operate in a "sweep" frequency mode - stepping sequentially through the 16 frequencies repeatedly.

(D) Two Frequency Operation - On command the experiment will continuously sample an arbitrary pair from A (8 choices)

(E) Single Frequency Operation - On command the experiment will lock on a specified observing frequency. (16 choices)

5c-1.2 Command Execution Monitoring
Verification of all commands should appear as an experiment mode readout in TM format.

5c-1.3 Criticality of Commands
No critical commands are forseen.

5c-1.4 Required accuracy of time of Execution. Deviation of 10 minutes from requested time is generally acceptable.

5c-1.5 Command Profile

5c-1.5.1 Profile during countdown - Radiometer 1 will be operating in mode A

5c-1.5.2 Profile During Switch-On - Following Injection

5c-1.5.2.1 Nominal Switch-On Sequence. Radiometer 1 in Mode A until further notice.

5c-1.5.2.2 Contingency Plans for Switch-On Sequence. Radiometer 1 or 2. Modes by order of preference A,C,D,E. Remain in same configuration until further notice.

5c-1.5.3 Profile During Normal Mission

5c-1.5.3.1 Normal Profile Radiometer 1 in Mode A with occasional (perhaps 2 per month) requests for other modes

5c-1.5.3.2 Contingency Plans. A choice will be made for the best of the available modes.

5c-2 Description of Data

5c-2.1 Engineering Data

5c-2.1.1 Engineering Telemetry List and Description. 3 voltage monitors for radiometer power supplies
3 temperature monitors

5c-2.1.2 Sampling Rates
A sampling rate of approximately once per hour is sufficient.

5c-2.2 Scientific Data

5c-2.2.1 The scientific data consist of one output from the radiometer which contains a measure of the antenna temperature and auxiliary outputs for attenuator setting and frequency indicator. These will all go into the DPU which serves Exp 5.

5c-2.2.2 The Block Length is 304 bits.

5c-2.2.3 Sampling Rates. The 304 bits in a block are generated in one S/C rotation and stored in a memory. After they are telemetered to Earth another S/C rotation of data is put in memory for transmission. At normal data rates several rotations will be lost between those which are accepted by the memory.

5c-3 Presentation of Data

5c-3.1 Real Time Presentation

5c-3.1.1 Engineering Real Time Presentation

5c-3.1.1.1 Real Time Profile
The voltage and temperature

readings constitute only a few readings per hour. They are needed only in the early phases of the flight or for any critical developments in the S/C later.

5c-3.1.1.2 The voltage and temperature readings will be interpreted by hand via calibrations.

5c-3.1.1.3 Method of Real Time Presentation A tabular listing is adequate.

5c-3.1.2 Scientific Time Profile. Data are needed for several days after launch and experiment turn-on.

5c-3.1.2.2 Description of Data. The antenna noise temperature is determined by hand via calibration curves from the radiometer output voltage, the attenuator setting and the temperature of the electronics.

5c-3.1.2.3 Method of Real Time Presentation. A display receiver output voltage vs time is required for each frequency for evaluation of system performance.

5c-3.2 Quick Look Presentation

5c-3.2.1 Engineering Quick Look Presentation. The same requirements as discussed

in 5c-3.1.1 will apply to Quick Look engineering data to detect malfunctions throughout the mission.

5c-3.2.2 Scientific Quick Look Presentation

5c-3.2.2.1 Quick Look Profile. Several hours of data are required at least once per week

5c-3.2.2.2 Description of Quick Look Data. Same as 5c-3.1.2.2

5c-3.2.2.3 Method of Data Transmitted.

5c-3.2.2.2 Method of Data Presentation Same as 5c-3.1.2.3

5c-4 Operational Mode Status Monitoring

5c-4.1 Monitoring Points

5c-4.2 Method of Display

5c-4.3 Method of Recording Notes

APPENDIX A 3

Reliability and Quality Assurance Provisions for Helios

Project Instruments

S-702-P-1A
August 7, 1970
Superseding
S-702-P-1
July 15, 1970

GSFC SPECIFICATION

FOR

RELIABILITY AND QUALITY ASSURANCE PROVISIONS FOR HELIOS PROJECT INSTRUMENTS

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

S-702-P-1A
August 7, 1970
Superseding
S-702-P-1
July 15, 1970

GSFC SPECIFICATION
FOR
RELIABILITY AND QUALITY ASSURANCE PROVISIONS FOR HELIOS PROJECT INSTRUMENTS

Prepared by: R. V. Gerace 8/5/70
R. V. Gerace Date
HELIOS Quality Engineer

Approved by: G. W. Ousley 8/10/70
G. W. Ousley Date
HELIOS Project Manager

Approved by: for Stanley Corn 8/10/70
R. A. King Date
Head, Quality Engineering Branch

Approved by: R. E. Dorrell 8/11/70
R. E. Dorrell Date
Chief, Quality Assurance Division

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

Contents

Appendix

1. SCOPE

1.1 INTRODUCTION. This specification sets forth the minimum reliability and quality assurance (R&QA) provisions required for HELIOS project instruments.

1.2 RELATION TO OTHER CONTRACT REQUIREMENTS. To the extent that any inconsistencies exist between the contract schedule and this specification, the contract schedule shall take precedence.

2. APPLICABLE DOCUMENTS

2.1 GENERAL. The following documents form a part of this specification to the extent described herein and in the contract.

2.2 NASA HANDBOOKS

2.2.1 NHB 5300.4(1A) - (Formerly NPC 250-1), "Reliability Program Provisions for Aeronautical and Space System Contractors," April 1970 Edition.

2.2.2 NHB 5300.4(1B) - (Formerly NPC 200-2), "Quality Program Provisions for Aeronautical and Space System Contractors," April 1969 Edition.

2.2.3 NHB 5300.4(3A) - "Requirements for Soldered Electrical Connections," May 1968 Edition.

2.3 GSFC Documents

2.3.1 S-312-P-1 - "GSFC Specification for Contractor Malfunction Reporting," March 24, 1970.

2.3.2 GSFC Preferred Parts List, Latest edition in effect on date of Request for Proposals.

2.4 DOCUMENTATION SUBMITTAL. The contractor shall submit all documentation specified herein and tabulated in Appendix A. The definitions of approval, review, and information in Section 1B103 of NHB 5300.4(1B) apply to this requirement. The contractor shall prepare a milestone chart for documentation submittal and distribution.

3. REQUIREMENTS

3.1 QUALITY ASSURANCE. The contractor shall establish and maintain an effective quality program to satisfy, as a minimum, the following provisions of NASA Handbook NHB 5300.4(1B):

3.1.1 Chapter 1: Introduction. All paragraphs.

3.1.2 Chapter 2: Quality Program Management and Planning.
Paragraph 1B200 General.
Paragraph 1B201 Organization.
Paragraph 1B202-1 Training
Paragraph 1B206 Quality Program Plan

3.1.3 Chapter 3: Design and Development Controls.
All paragraphs.

3.1.4 Chapter 4: Identification and Data Retrieval.
Paragraph 1B400 General.
Paragraph 1B401 Identification Methods.
Paragraph 1B402 Documentation.

3.1.5 Chapter 5: Procurement Controls.
Paragraphs 1B500 through 1B506.

3.1.6 Chapters 6 through 13. All paragraphs.

3.2 RELIABILITY. The contractor shall implement a reliability program in accordance with the following provisions of NASA Handbook NHB 5300.4(1A):

3.2.1 Chapter 1: Scope. All paragraphs.

3.2.2 Chapter 2: Reliability Program Management.

Paragraph 1A201-1, Reliability Program Plan.

Paragraph 1A205-3, Supplier Control.

3.2.3 Chapter 3: Reliability Engineering.

Paragraph 1A303-1, Failure Mode, Effect and Criticality Analyses.

Paragraph 1A305, Design Review Program.

Paragraph 1A306, Problem/Failure Reporting and Correction.

Paragraph 1A308, Parts and Materials Program

3.2.4 Chapter 4: Testing and Reliability Evaluation.

Paragraph 1A402-2, Testing-Qualification of Hardware.

Paragraph 1A402-3, Testing - Test Specifications, Procedures and Reports.

3.3 PROPOSED R&QA PROGRAM PLANS. The contractor shall submit a Reliability Program Plan and a Quality Program Plan with his proposal. The plans shall describe how the contractor will ensure compliance with the required R&QA provisions and use the same paragraphing format of NHB 5300.4(1B) and (1A). The contractor shall also submit a cost estimate for each element in the Program Plans.

3.4 SOLDERING. The contractor shall establish and maintain a soldering program meeting the requirements of NASA Handbook NHB 5300.4(3A).

3.4.1 The documents required by paragraph 3A207 shall be submitted to the designated GSFC QA representative for review.

3.5 CONFIGURATION CONTROL. The contractor shall submit a proposed and a final Configuration Control Plan to describe the contractor's formal means of technical evaluation, documentation accounting, and approval of changes to end-items in accordance with GSFC requirements for Configuration Control.

3.6 MALFUNCTION REPORTING. The contractor shall report malfunctions to GSFC as required by S-312-P-1.

3.7 PREFERRED PARTS LIST. The contractor shall select parts from the GSFC Preferred Parts List (PPL). Parts not on the PPL will be considered as "Non-Standard Parts" and will require the approval of the Parts Branch, Code 311, GSFC. The contractor shall submit appropriate data as necessary to justify the use of any non-standard part.

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APPENDIX A

R&QA DOCUMENTATION SUBMITTAL CHART

DOCUMENT	REF.	SUBMIT FOR APPR	SUBMIT FOR REV.	SUBMIT FOR INFO.	SEND TO:	QTY.	DUE
C Proposed Quality Program Plan	S-702-P-1		x		Project Off.	5	With Proposal
1 → Quality Program Plan	1B206	x			Project Off.	5	Within 30 days after award
Change Control System Document	1B302		x		Project Off.	5	With Configuration Control Plan
Test Specifications, Inspection and Test Procedures, and End-Item Inspection and Test Specs and Procedures	1B702, 1B703, and 1B704	x			Project Off.	5	30 days prior to start of appl. test
End-Item Insp. & Test Report	1B705-7			x	Project Off.	5	With documentation package
Written Requests for NASA C.O. Approval	1B805	x			Contract.Off.	5	When written
Documentation Package	1B1102-2			x	With End-Item	5	With shipment
2 → Proposed Reliability Program Plan	S-702-P-1		x		Project Off.	5	With Proposal
C Reliability Program Plan	1A201	x			Project Off.	5	Within 30 days after award
Design Review Input Packages	1A305-1			x	Project Off.	10	15 working days before meeting
Design Review Meeting Minutes	1A305-1			x	Project Off.	10	5 working days after meeting
Design Review Reports	1A305-1			x	Project Off.	10	30 days after meeting
Parts, Devices, & Materials Specs.	1A308-4		x		Project Off.	5	With Parts, Device, & Matr. List
Parts, Devices, & Materials Qualif. Test Specs. & Reports	1A308-5		x		Project Off.	5	With Parts, Device, & Matr. List
Parts, Devices, & Materials Lists	1A308-6	x			Project Off.	5	60 days prior to initiation of detailed design
Parts, Devices, & Materials Application Review	1A308-7		x		Project Off.	5	With Design Review Input Package
Qualification Status List	1A402-2		x		Project Off.	5	With Parts, Device & Matr. List
GSFC Malfunction Report Form 4-2	S-312-P-1	x			Project Off.	-	As required by S-312-P-1
No. Configuration Control Plan	S-702-P-1	x			Project Off.	5	Within 60 days after award
Nb Proposed Configuration Control Plan	S-702-P-1		x		Project Off.	5	With Proposal

APPENDIX B

Reliability Analysis for Helios Dual Swept Frequency Radiometer

System

RELIABILITY ANALYSIS FOR HELIOS DUAL SWEPT FREQUENCY RADIOMETER SYSTEM

RELIABILITY ANALYSIS

FOR

HELIOS DUAL SWEPT FREQUENCY RADIOMETER SYSTEM

1.0 INTRODUCTION

This is a qualitative failure mode analysis of the Radiometer system developed by Washington Technological Associates for the NASA Goddard Space Flight Center under Contract No. NAS 5-11396.

The reliability estimate (calculation enclosed) gives a value of .861, well within the reliability goal of .80 given by the specifications.

The estimate is based upon reliability data available in MIL Handbook 217B and on the use of the newly manufactured oscillators installed in flight systems 1 and 2. By using factors for space use, failure rates were obtained for the components used and the reliability of the system was calculated.

The failure rate for the hybrid oscillators was calculated on the basis of discrete components. It is a fair assumption that if the assembly process is mature and accurately controlled, the hybrid assembly will be more reliable than a printed circuit board or a cordwood construction unit because the number of connections is reduced by one-third to one-half.

The first oscillators built demonstrated an abnormally high failure rate. This was traced to incomplete removal of trichlorethelyne used in the cleaning process. Premature failure was discovered on a number of units, including some of the units in prototypes 1 and 2. The process was changed and tightly controlled with the Government witnessing at every step in the process for flight 1 and 2. As a result, we do not know of a single operational failure of these new oscillators.

Recently, however, it has been reported that the unit in B spacecraft, i.e. the flight 2 radiometer, shows some signs of instability that may or may not result in a failure. The suspected channels are two channels on radiometer A and one channel on radiometer B. If one assumes that the two channels on radiometer A fail, then the experienced failure rate is 1.97×10^{-5} rather than the $.394 \times 10^{-5}$ predicted. Using 1.97×10^{-5} in the reliability calculations shows the reliability of radiometer A to be .693 and the redundance reliability of the radiometer system to be .8045.

2.0 DEFINITION OF THE SYSTEM

The Helios Dual Swept Frequency Radiometer system is designed to measure the amplitude of a differential signal obtained from a pair of monopole antennas mounted on the Spacecraft, in the radio spectrum between 26.5 khz. and 3 Mhz. The measurement of the amplitude of the differential signal is derived from samples of amplitude at sixteen discrete frequencies, which are obtained from a continuous sweeping of the entire band. Amplitude calibration is obtained by means of an internal source of constant value.

3.0 CONFIGURATION OF THE SYSTEM

The system is shown in simplified block diagram and in the complete schematic blueprint attached to this report.

The two antennas are mounted on the spacecraft 180 degrees apart to obtain the differential component of the field; they feed separately into the two pre-amplifiers. These preamps are matched for gain and phase shift and their gain is automatically controlled by the radiometer to obtain a range of 90 db. An internal noise source for calibration purposes is included, and is controlled by a relay.

The outputs of the two pre-amplifiers are connected differentially to the input of the Radiometer's amplifiers.

The two radiometers are used in standby redundancy and consist of the following main components:

a) The super heterodyne amplifier with sixteen separate local oscillators, a mixer, crystal filter, I.F. amplifier, detector, and log amplifier.

b) The range control circuit (which automatically modifies the gain of the pre-amplifiers and telemeters the appropriate gain flags).

c) The telecontrolled logic command for the switching of the local oscillators, the noise calibration signals and redundancy command.

4.0 DEFINITIONS OF OPERATING STATUS

For the purpose of this Failure Analysis, the system is assumed to have successfully survived the launching stresses and to operate in space vacuum within a temperature range of -20 to +70 degrees Centigrade.

A failure is defined as the complete absence of the signal indicating the level of radiation to be measured, and/or the absence of the range flag.

A partial failure is defined as any irregularity in the radiation level signal, whether this is produced by improper calibration, improper frequency sweeping or other anomaly.

A successful operation is obtained whenever the signal level is transmitted at all frequencies established and the level flags show proper performance of the gain control system.

5.0 FAILURE MODE ANALYSIS FORMAT

The enclosed failure mode analysis is made at the subassembly level; the effect of the failure of the individual parts in the short and open mode is the effect on the particular subassembly considered.

Each subassembly is indicated by the title sheet, the parts list, and the failure mode and effects sheet.

For example, the first analysis is on the Pre-amplifier, and the effect of the failure short is the failure or partial failure of the pre-amplifier, not of the total system. In the case of the Radiometer, its subassemblies are listed on the parts list of the Mother Board PC 731. With the exception of the oscillators, all subassemblies of the Mother Board are essential to the operation of the radiometer; therefore, the indication of failure of the subassembly is a direct indication of the failure of the radiometer. The failure of any one of the 16 oscillators would imply only failure of the radiometer to transmit that particular frequency of the faulty oscillator, and should therefore be considered only a partial failure of the radiometer.

In other words, the effect of redundant configurations is not indicated in the analysis sheets, but will be considered only in the discussion.

6.0 DISCUSSION OF ANALYSIS RESULTS

6.1 Pre-amplifiers

The two amplifiers are matched to eliminate as much local interference and self-generated noise as possible; however, since each pre-amplifier can be calibrated separately from the ground, one can still obtain a calibrated signal in the radiometer even with one of the two pre-amplifiers not functioning. Depending upon the amount of internally generated noise and local interference, the failure of a pre-amplifier can be considered a partial failure of the system, even though the two pre-amplifiers are not strictly connected in redundant configuration. The very large percentage of parts at the 0.001 established level of failure rate makes this configuration highly acceptable.

6.2 Radiometer

The two radiometers are in redundant configuration as explained previously and therefore, no signal part failure will produce a system failure. In this sub-assembly, the large

number of component parts purchased to low established failure rate levels, and the highly derated operating conditions assure a long failure-free operation.

7.0 NON-REDUNDANT ELEMENTS

The Noise Source is the larger non-redundant element in the system, its function, however, cannot be considered absolutely essential to the operation of the system, because the system is calibrated completely before launch with a much more accurate signal source. Its use in space is needed only in the event of a variation in the received signals, to determine if they are produced by a failure in the system or some other malfunction in the rest of the satellite.

Other non-redundant elements in the system that must be considered critical are: the redundancy switching, the transformer board, and the command interface.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This failure analysis has shown a well-balanced design configuration of the various components in the system, with redundancy used only at the largest components level giving adequate assurance of reliable performance of the system.

A large percentage of the parts used have established reliability levels or were selected from the Preferred Parts List; however, many parts had to be qualified.

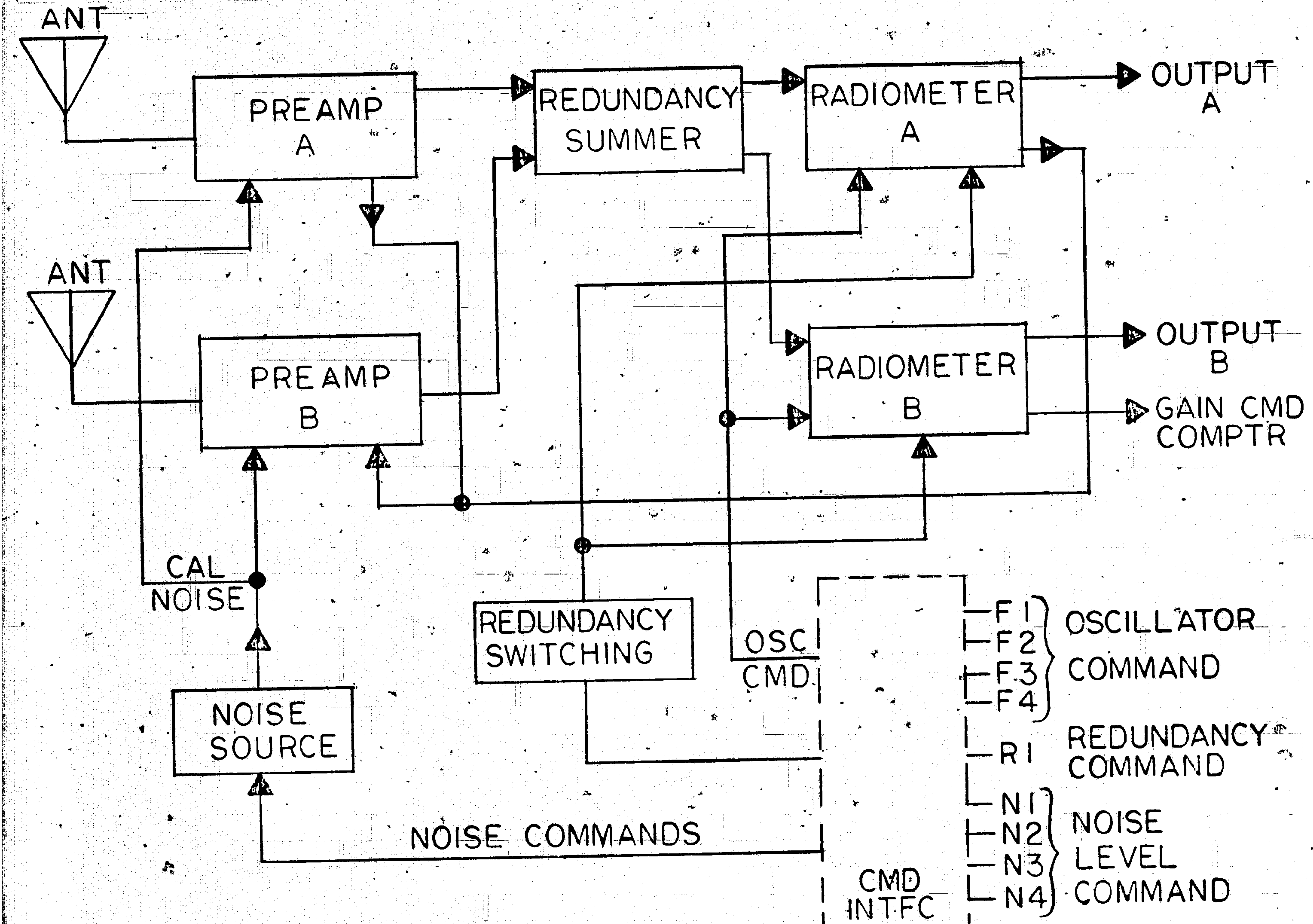
It is interesting to note that the preliminary reliability analysis delivered on October 3, 1972 relied primarily on estimated data for most parts. The failure rate presented in the final report is higher by a factor of approximately 2.5 but the reliability estimate for the radiometer dropped only from .992 to .970. This small drop is largely because of the redundancy of the radiometer. It can also be seen that if the oscillator failure rate is assumed to be twice as great as presented ($.394 \times 10^{-5}$ to $.788 \times 10^{-5}$) the radiometer reliability decreases from .970 to .952 and the system reliability decreases from .861 to .845. As previously shown if two oscillators fail the rate is increased from $.394 \times 10^{-5}$ to 1.97×10^{-5} and the system reliability decreases from .861 to .8045.

RELIABILITY ESTIMATE

FOR

HELIOS DUAL SWEPT FREQUENCY RADIOMETER SYSTEM

ELEMENT	FR(10^{-5})	FRT	RELIABILITY e^{-FRT}	REDUNDANCE RELIABILITY
Preamp	.446	.0446	.956	.998
Mixer	.22			
Filter	.062			
AGC	.253			
Oscillator	.394			
Mother Board	.016			
Output Card	.426			
IF amp	.093			
Amp	.195			
Logic 1	.126			
Logic 2	.136			
Logic 3	.177			
TOTAL RADIOMETER	2.088	.2088	.8196	.970
Noise Source	.265			
Noise Switch	.406			
TOTAL NOISE	.671	.0671	.935	
Redundancy Sw.	.066	.066	.993	
Transformer	.055	.0055	.985	
Command Interface	.265	.0265	.973	
TOTAL SYSTEM RELIABILITY				.861



SIMPLIFIED BLOCK DIAGRAM

APPENDIX C

Helios Radiometer Experiment 5C Test Plan

HELIOS EXPERIMENT 5C TEST PLAN

Prepared for

National Aeronautics Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771
Code 693

NASA Contract # NAS 5-11396

Prepared by

Washington Technological Associates, Inc.
979 Rollins Avenue
Rockville, Maryland 20852

A Subsidiary of Quanta Systems Corporation

WTA No. 3436

13 July 1973

HELIOS EXPERIMENT 5C TEST PLAN OUTLINE

1.0 GENERAL

2.0 ELECTRICAL TESTS

- 2.1 Crystal Filter Bandwidth
- 2.2 Crystal Oscillator Stability
- 2.3 Log Amp Stabilization
- 2.4 Noise Source Calibration
- 2.5 Preamp Operation
  - 2.5.1 Input Z
  - 2.5.2 Phase Matching
  - 2.5.3 Gain Matching
- 2.6 Post Detection Time Constant
- 2.7 Output Voltage Stability
- 2.8 Power Consumption
- 2.9 Precalibration
- 2.10 Calibration (computer)
  - 2.10.1 Calibration (without computer)

3.0 MECHANICAL TESTS

- 3.1 Weight

1.0 GENERAL

The purpose of this test plan is to provide testing and operating procedures for qualifying and operating the HELIOS Radiometers. This plan includes operating procedures, electrical tests, mechanical measurements, integration, and environmental tests.

1.1 Test Equipment

All test equipment used to test or operate this experiment must be calibrated at the time of the test, as defined in the WTA Quality Assurance Handbook and as monitored by the appropriate DCAS Representative(s).

1.2 Test Documentation

Each test must be recorded on data sheets made for that purpose or in data notebooks, as appropriate. Each entry must be dated, signed, and the test equipment used noted.

2.0 ELECTRICAL TEST

The purpose of electrical testing is to verify that the equipment meets the electrical specifications of GSFC Specification S-693-P-2 as amended by Contract NAS 5-11396.

Certain electrical tests can best be accomplished before the Radiometer is packaged, i.e., Items referenced in 2.2, 2.3, 2.4, 2.5 - all others are tested with a complete Radiometer.

2.1 Crystal Filter Bandwidth

The purpose of this test is to demonstrate that the following specifications are valid:

1. Bandwidth - 10 kHz ± 1 kHz at 3 db points.
2. Skirt Selectivity

Bandwidth

10 kHz - < -3 db

23 kHz - > -60 db

Ripple - <.3 db

This test is made with the Radiometer connected to and operated by the GSE, but without preamps. Connect the Radiometer and test equipment as shown on figure 2.1-1. Operate the Radiometer as outlined in Appendix A. Turn on GSE and Radiometer power and adjust the channel selector to Channel 10. The filter response should now show up on the screen. Measure and record the 3 db and 60 db bandwidth and ripple at room temperature.

Data from this test should be recorded on Test Data Sheet 2.1-1.

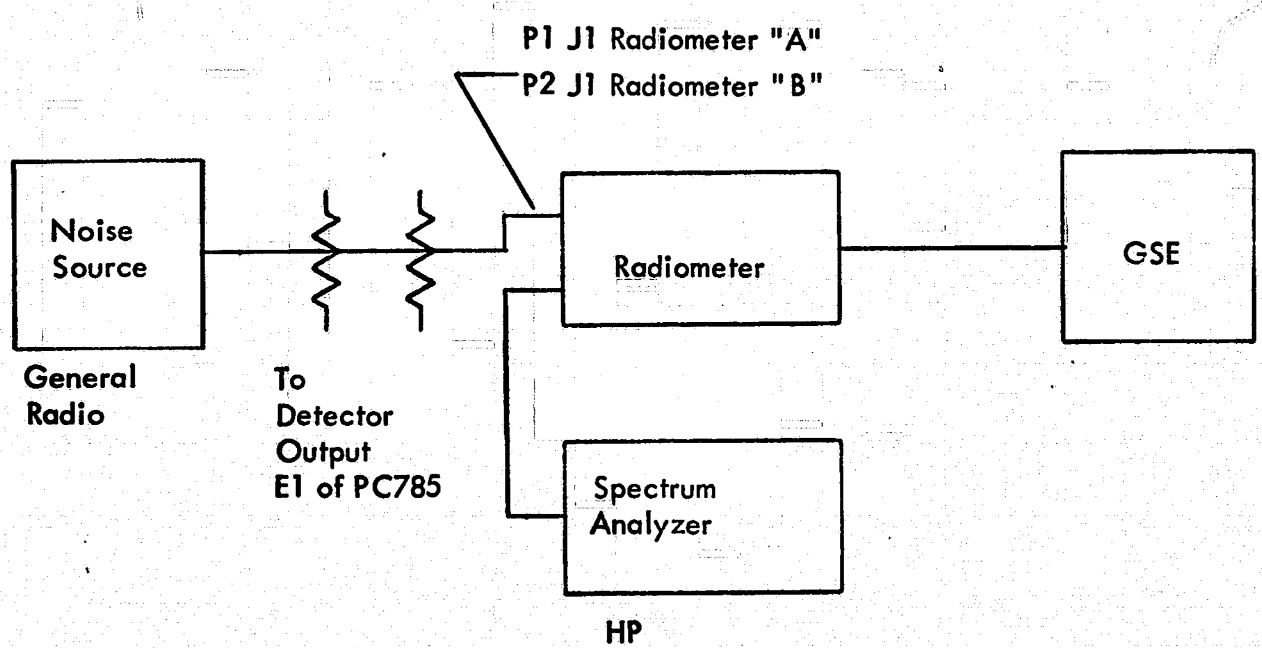

P1 J1 Radiometer "A"
P2 J1 Radiometer "B"
Noise Source
General Radio
To Detector Output E1 of PC785
Radiometer
GSE
Spectrum Analyzer
HP

Figure 2.1-1

Test Data Sheet 2.1-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Crystal Filter - S/N________

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.1-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date __________ Time Started __________ Time Ended __________

Crystal Filter - S/N ________

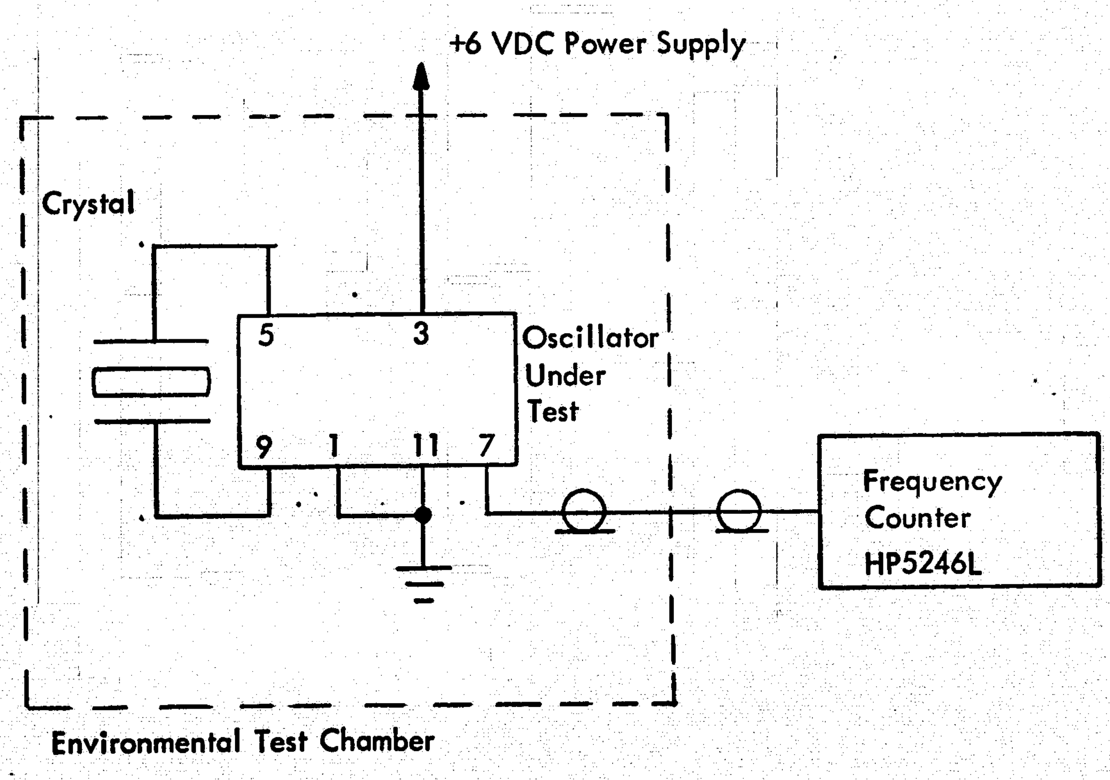
	Temperature		
	25° C	-20° C	+60° C
f_c	______	______	______
3db Bandwidth	______	______	______
Ripple	______	______	______

2.2 Crystal Oscillator Frequency Stability

This test is used to determine the total frequency variation over the temperature range of -20° to +60° C. Because of monitoring difficulty, this test must be performed with each oscillator as a separate entity.

Set up equipment as indicated in figures 2.2-1 and 2.2-2. Note the output frequency at +25° C, -20° C, and +60° C. Subtract the maximum positive and negative excursions. The result is the total frequency variation of the oscillator.

Data from this test should be recorded on Test Data Sheets 2.2-1 and 2.2-2.



Test Data Sheet 2.2-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Radiometer A - Crystal Oscillator

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.2-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ______ Time Started ______ Time Ended ______

Radiometer A - Crystal Oscillator

Channel	S/N	Frequency @ 25° C	Frequency @ -20° C	Frequency @ +60° C
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

Test Data Sheet 2.2-2
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date____________ Time Started____________ Time Ended____________

Radiometer B - Crystal Oscillator

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.2-2
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ____________ Time Started ____________ Time Ended ____________

Radiometer B - Crystal Oscillator

Channel	S/N	Frequency @ 25° C	Frequency @ -20° C	Frequency @ +60° C
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

2.3 Log Amp Stabilization

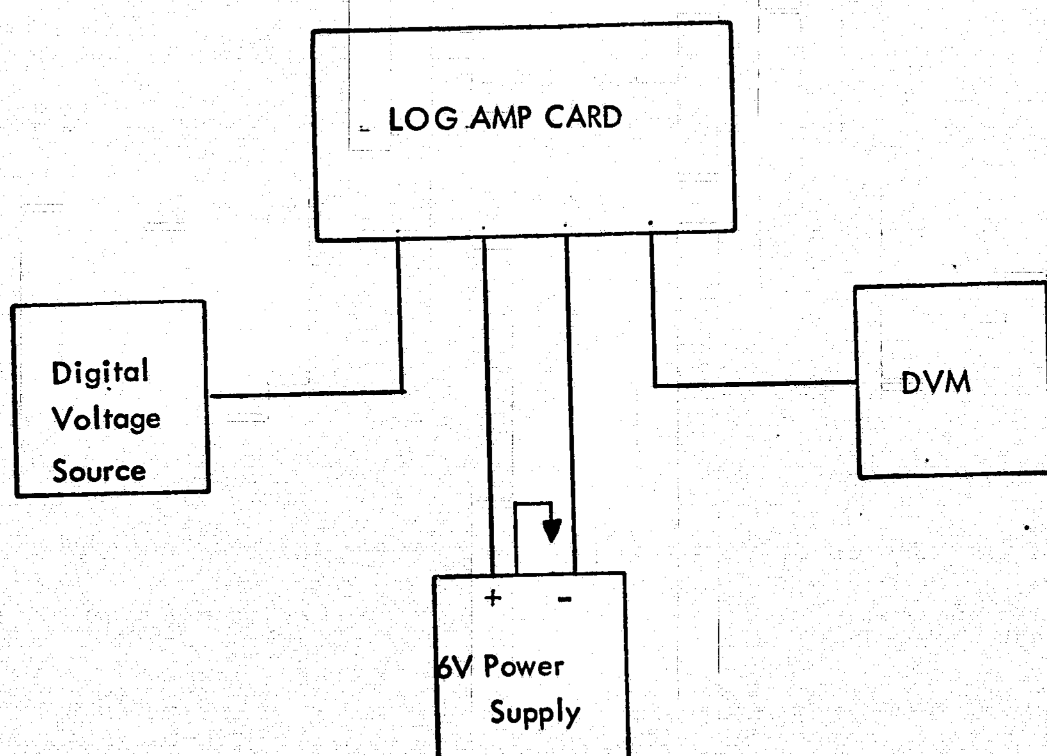
Test procedure for the log amplifier.

Connect ± 6V supply to the proper terminals of the board.

Record the current for ± supply.

Connect the test equipment as shown below:

TEST CONNECTIONS



2.3.1 Vary input voltage in seven steps as shown below and record output voltage at DVM with ambient temperature at -10° C room temperature and $+60^\circ$ C.

Input (mv)	Output (volts)
- 4 mv	
-10 mv	
-20 mv	
-40 mv	
-100 mv	
-250 mv	
-400 mv	

Test Data Sheet 2.3.1-1 should be used to take data for this test.

Test Data Sheet 2.3.1-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Log Amp

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.3.1-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ________ Time Started ________ Time Ended ________

Log Amp

S/N ________

Input	+25° C Output	-20° C Output	+60° C Output
10 mv	____	____	____
20 mv	____	____	____
40 mv	____	____	____
100 mv	____	____	____
250 mv	____	____	____
400 mv	____	____	____

S/N ________

Input	+25° C Output	-20° C Output	+60° C Output
10 mv	____	____	____
20 mv	____	____	____
40 mv	____	____	____
100 mv	____	____	____
250 mv	____	____	____
400 mv	____	____	____

2.4 <u>Noise Source Calibration</u>

This test is used to determine the frequency response, and variation of output level over temperature, of the noise source assembly PC-722. Because of monitoring difficulty, this test must be performed with the noise source as a separate entity. Set up equipment as indicated in figure 2.4-1. Record the output level at +25° C, -20° C, and +60° C. Also, plot the output level versus frequency at +25° C on a graph. Switching either S1 or S2 to -6 VDC should reduce the output level by approximately 20db. Switching both S1 and S2 should reduce the output level by 40db.

Data from this test shall be recorded on Test Data Sheet 2.4-1.

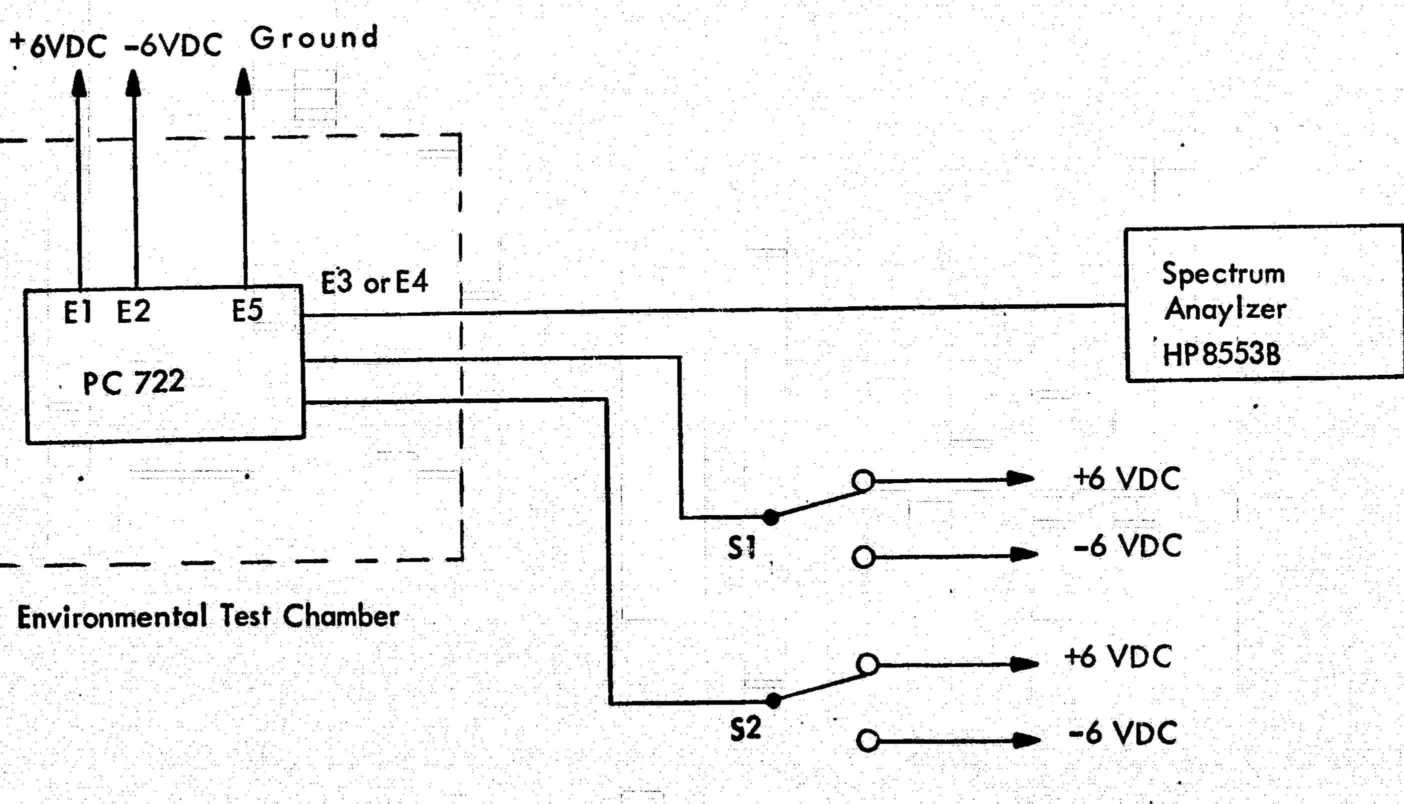


Figure 2.4-1

Test Data Sheet 2.4-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Noise Source Output Level

S/N________

Test Conditions:

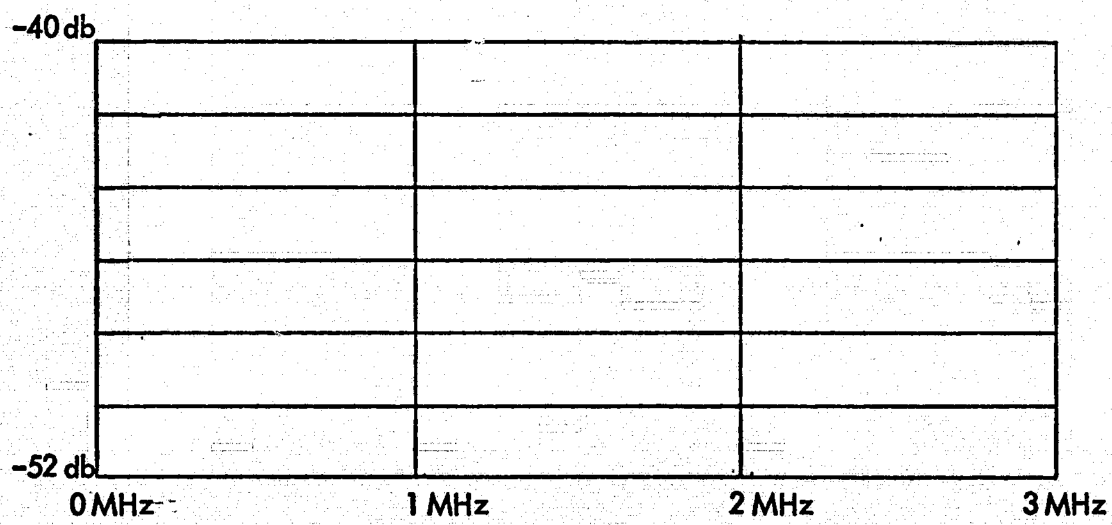
Test Equipment Connections:

Test Data Sheet 2.4-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date __________ Time Started __________ Time Ended __________

Noise Source Output Level

S/N ________	TEMPERATURE 25° C	-20° C	+60° C
10 kHz	______	______	______
500 kHz	______	______	______
1 MHz	______	______	______
2 MHz	______	______	______
3 MHz	______	______	______



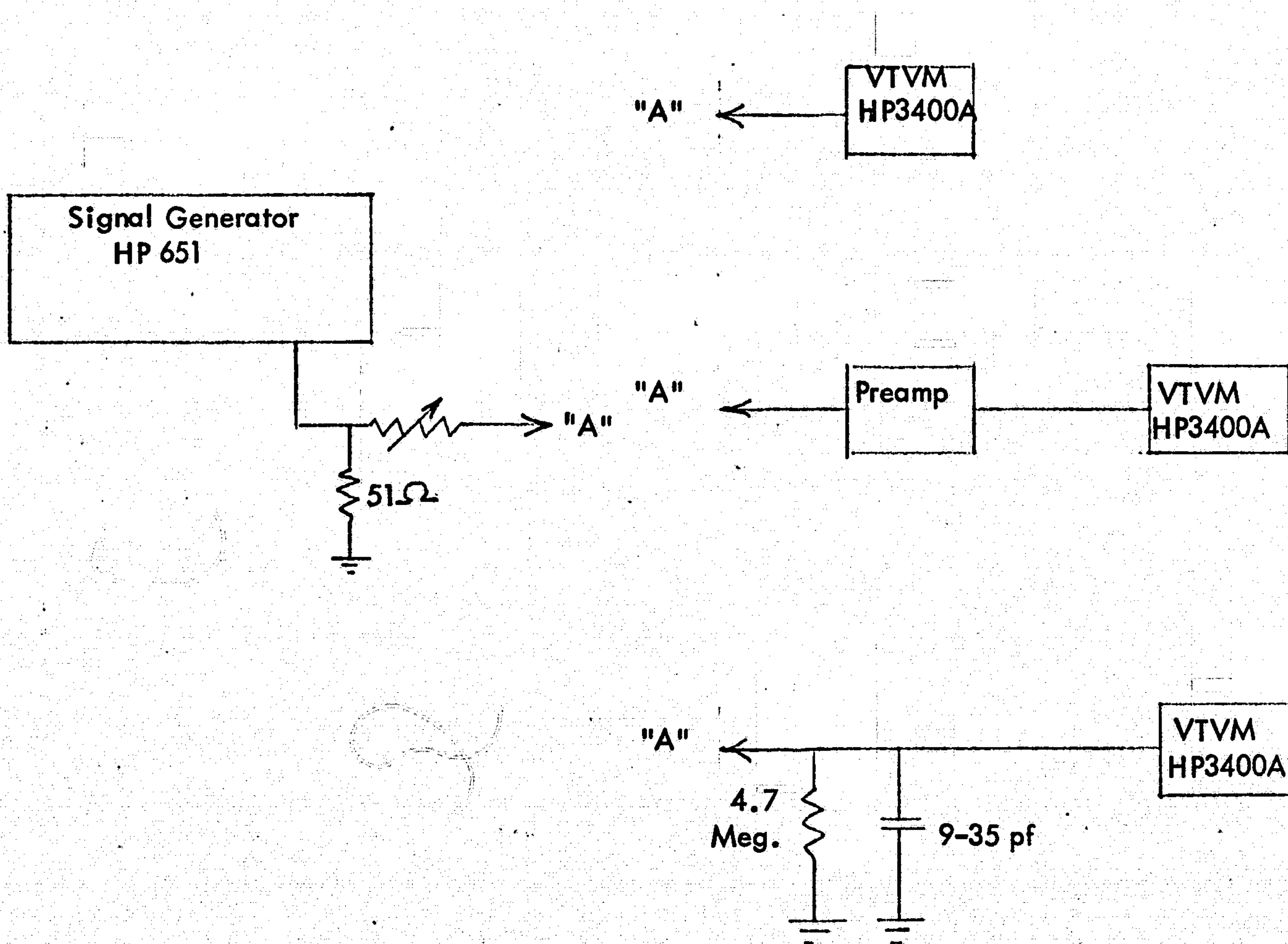
2.5 Preamp Operation

2.5.1 Preamp Input Impedance

This test is used to determine the input impedance of the preamp assembly PC-716.

Set up equipment as indicated in figure 2.5.1-1, Mode "A". Set the signal generator to 20 kHz and note the output level. Change to Mode "B" and adjust the potentiometer for a 3 db reduction in output level. Measure and record the potentiometer resistance. Repeat this procedure at every octave up to 3 MHz. Change to Mode "C". Adjust the signal generator to 20 kHz; adjust the potentiometer to the resistance obtained with the preamp at 20 kHz, and return to Mode "A" - the output level should be the same as that obtained in Mode "A" above. Adjust the frequency to 3 MHz. Adjust the potentiometer to the resistance obtained with the preamp. Note the output level. Change to Mode "C" and adjust the capacitor for a 3 db reduction in output level. Return to Mode "A". Set the signal generator to 20 kHz and note the output level. Change to Mode "C" and adjust the potentiometer for a 3 db reduction in output level. Measure and record the potentiometer resistance. Repeat this procedure at every octave up to 3 MHz. Compare the results obtained in Modes "B" and "C". They should be the same. Measure the capacitor. The result is the equivalent input impedance.

Data from this test shall be recorded on Test Data Sheet 2.5.1-1.



"A"
VTVM
HP3400A
Signal Generator
HP 651
"A"
Preamp
VTVM
HP3400A
"A"
51Ω
"A"
VTVM
HP3400A
4.7
Meg.
9-35 pf

Fig. 2.5.1-1

Test Data Sheet 2.5.1-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Preamp S/N__________

Input Impedance

Temperature 25° C

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.5.1-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date __________ Time Started __________ Time Ended __________

Preamp S/N __________

Input Impedance

Temperature 25° C

Calibrate Test Set Up:

Frequency	Voltage Open Circuit	Terminated with 16pf/100 K's
20 kHz	______	______
200 kHz	______	______
500 kHz	______	______
1 MHz	______	______
2 MHz	______	______
3 MHz	______	______

2.5.2 Preamp Phase Matching

This test is used to determine the phase match of the preamps.

Set up equipment as indicated in figure 2.5.2-1(A). Zero the vector voltmeter. Set up equipment as indicated in figure 2.5.2-1(B). Vary the input frequency from 20 kHz to 3 MHz while monitoring the phase difference on the vector voltmeter. Record the maximum positive and negative excursions of phase. Repeat the above procedure in the mid and low gain modes. The total phase discrepancy should not exceed 6°.

Data from this test should be recorded on Test Data Sheet 2.5.2-1.

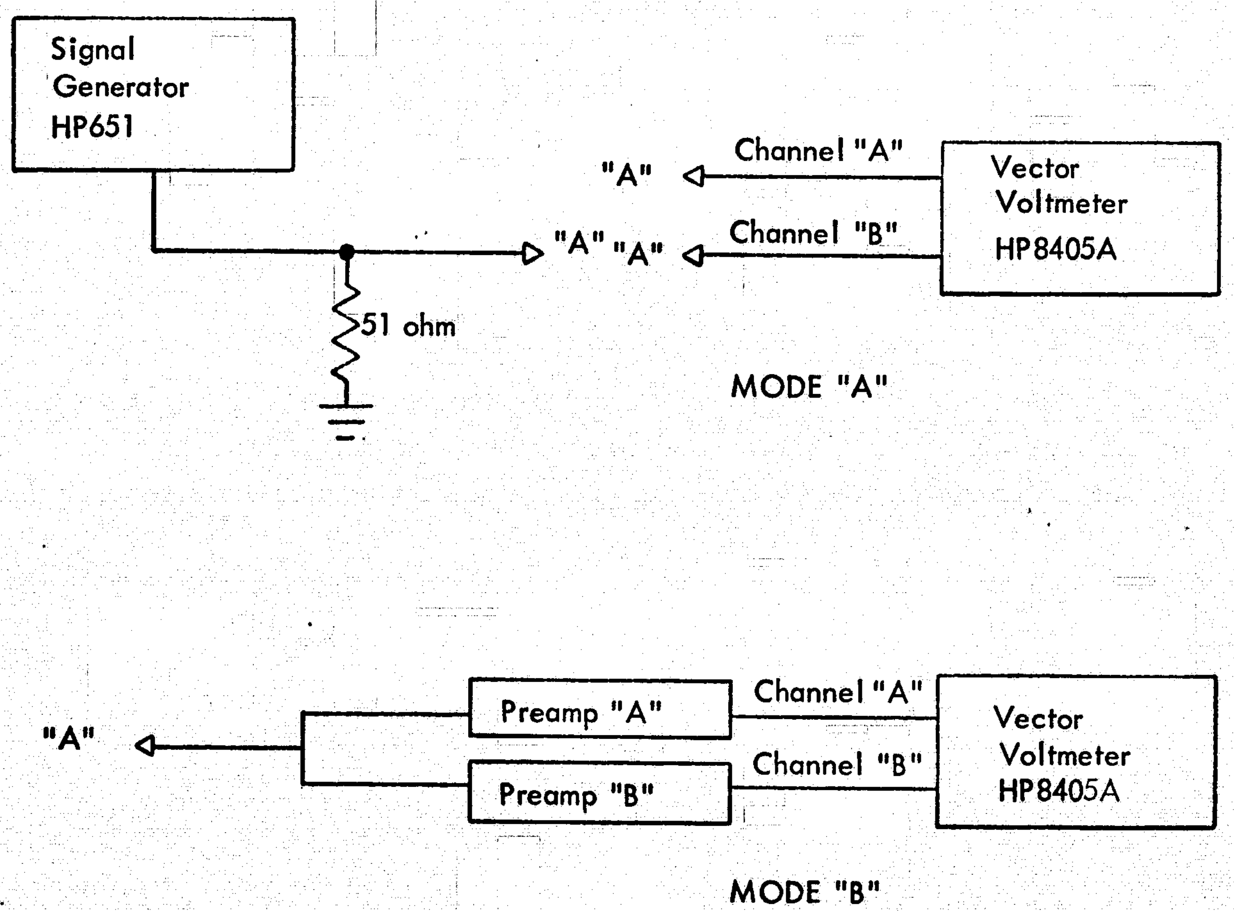


Figure 2.5.2-1

Test Data Sheet 2.5.2-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Preamp S/N__________ and__________

Phase Matching

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.5.2-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Preamp S/N__________ and__________

Phase Matching

	Phase (Relative)		
Frequency	@ 25° C	@ -20° C	@ +60° C
20 kHz	______	______	______
100 kHz	______	______	______
500 kHz	______	______	______
1 MHz	______	______	______
2 MHz	______	______	______
3 MHz	______	______	______

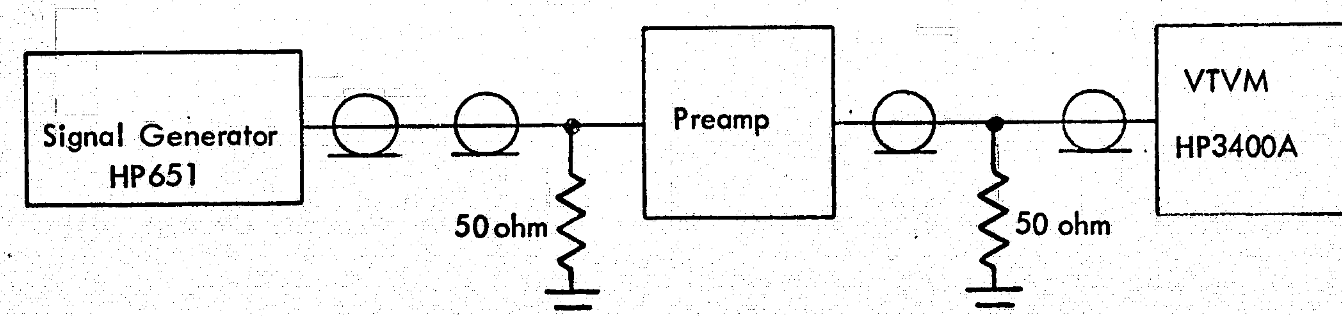
2.5.3 Preamp Gain Matching

The test is used to determine the gain match of the preamps.

Set the equipment as indicated in figure 2.5.3-1. Starting in the high gain mode at 20 kHz, record the gain at octave intervals up to 3 MHz. Repeat in the mid and low gain modes.

Change to the other preamp and repeat the above procedure. The gain plots of the two preamps should track to within 0.6 db across the frequency spectrum in all gain modes.

Data from this test should be recorded on Test Data Sheet 2.5.3-1.



Test Data Sheet 2.5.3-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Preamp S/N__________ and__________

Gain Matching

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.5.3-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Preamp S/N______ and ______

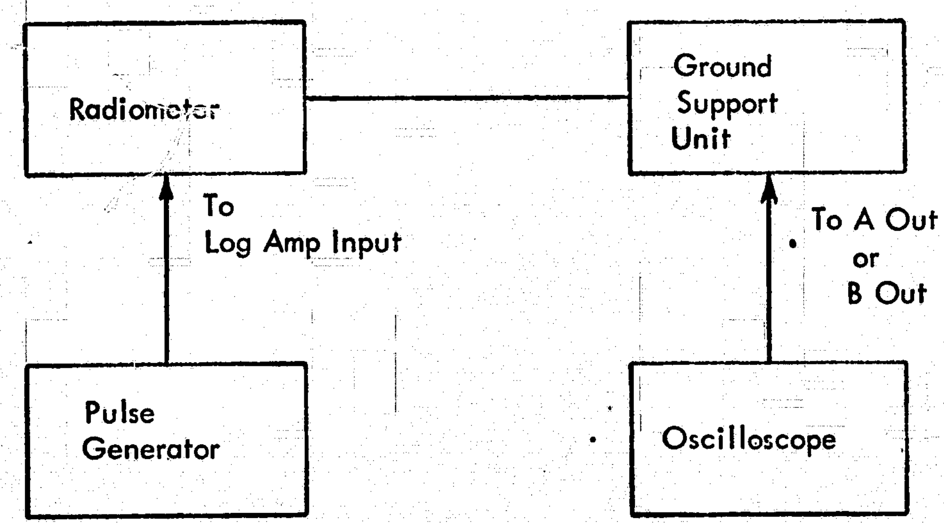
Gain Matching

	Temperature		
Frequency	25° C	-20° C	+60° C
20 kHz	______	______	______
100 kHz	______	______	______
500 kHz	______	______	______
1 MHz	______	______	______
2 MHz	______	______	______
3 MHz	______	______	______

2.6 Post Detection Time Constant

The test is used to determine the time constant of the output card PC-729. Set up equipment as indicated in figure 2.6-1. Inject a 100 msec pulse at a repetition rate of approximately 5 pps into the input of the log amp. Note the output waveform, it should indicate a time constant of 8.2 msec.

Data from this test shall be recorded on Test Data Sheet 2.6-1.



Test Data Sheet 2.6-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Post Detection Time Constant

S/N________and________

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.6-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Post Detection Time Constant

	Time Constant
S/N________	________
S/N________	________

2.7 Output Voltage Stability

The output voltage stability may be measured by monitoring the A out or B out jacks of the ground support unit. Data from this test shall be recorded on Test Data Sheet 2.7-1.

2.8 Power Consumption

The ± 6 VDC power consumption may be read directly from the front panel meters.

The +12 VDC power consumption may be measured by inserting a current meter into the line between Pins 31 and 32 of J2 on the Radiometer and Pin 23 of J3 on the ground support unit. Data from this test shall be recorded on Test Data Sheet 2.8-1.

2.9 Precalibration

This test is used to determine the functional capability of the Radiometer system.

Set up the equipment as indicated in figure 2.9-1. Set the ground support unit up for manual operation. Turn on the noise source and adjust the manual attenuation for -110db. Note the residual level. Adjust the manual attenuation to -100db and note the level. Keep reducing the attenuation in 10db steps while noting the output level. There should be a linear change in output for a log change in input level until the output reaches approximately 4.5 volts. At this point, the Radiometer should go to range two. Continue decreasing attenuation through ranges two and three until saturation is reached (approximately 5.0 VDC). A dynamic range of approximately 90db should be obtained. Repeat the above procedure on Channels 5, 10, and 16 at temperatures of 25° C, +60° C, and -20° C.

Data from this test shall be recorded on Test Data Sheets 2.9-1.

Precalibration is used only when calibration with the computer is anticipated.

Test Data Sheet 2.7-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Output Voltage Stability

Radiometer A - S/N________ Radiometer B - S/N________

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.7-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ________ Time Started ________ Time Ended ________

Output Voltage Stability

Radiometer A - S/N ________

Test	Time	Output Voltage
1	________	________
2	________	________
3	________	________
4	________	________
5	________	________
6	________	________

Radiometer B - S/N ________

Test		
1	________	________
2	________	________
3	________	________
4	________	________
5	________	________
6	________	________

Test Data Sheet 2.8-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Power Consumption

Radiometer A - S/N_______ Radiometer B - S/N_______

Test Conditions:

Test Equipment Connections:

Test Data Sheet 2.8-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Power Consumption

Radiometer A - S/N_______

	Normal		Calibrate	
	Minimum	Maximum	Minimum	Maximum
+ 6V	______	______	______	______
- 6V	______	______	______	______
+12V	______	______	______	______

Radiometer B - S/N_______

	Normal		Calibrate	
	Minimum	Maximum	Minimum	Maximum
+ 6V	______	______	______	______
- 6V	______	______	______	______
+12V	______	______	______	______

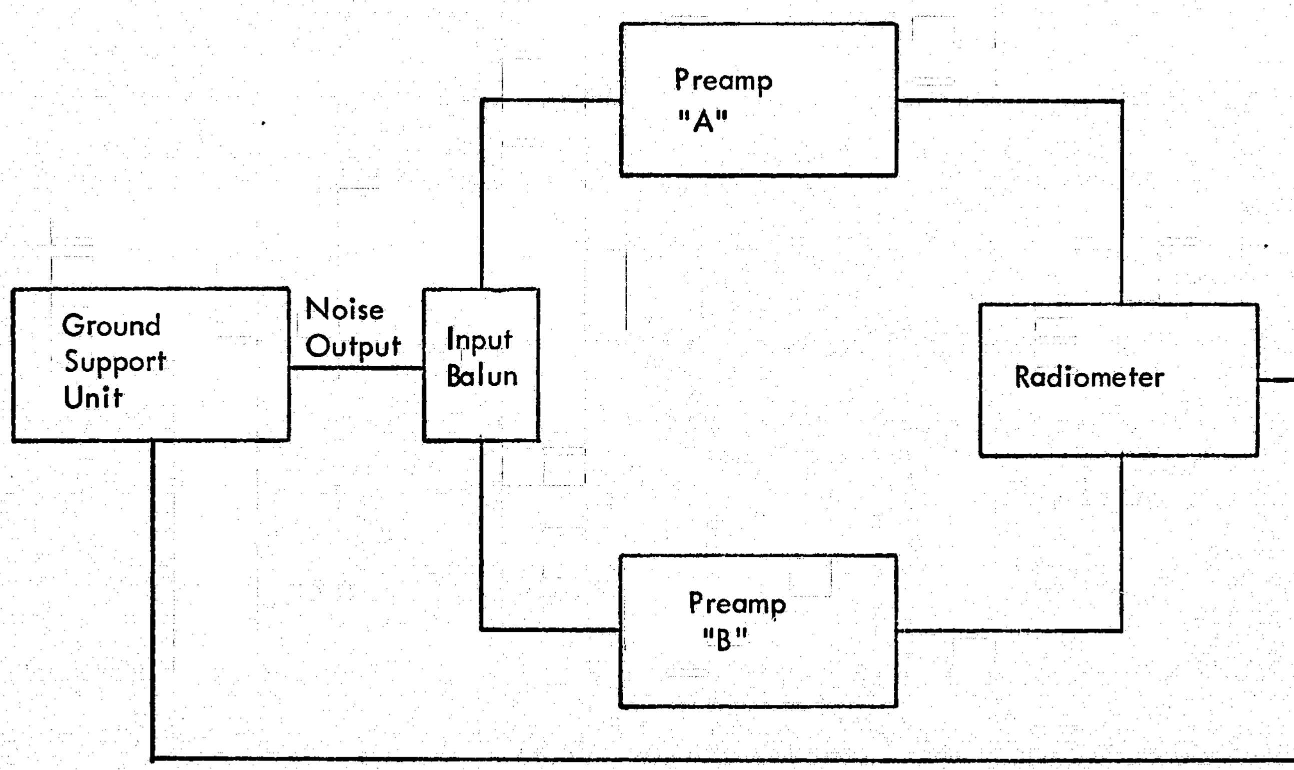

Preamp
"A"
Ground
Support
Unit
Noise
Output
Input
Balun
Radiometer
Preamp
"B"

Figure 2.9-1

Test Data Sheet 2.9-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date____________ Time Started____________ Time Ended____________

Mechanical Tests

Radiometer S/N________ Preamp S/N________ and________

Weight:

Radiometer - Unpotted __________

Potted __________

Preamp S/N________

Unpotted __________

Potted __________

Preamp S/N________

Unpotted __________

Potted __________

Test Data Sheet 2.9-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ____________ Time Started ____________ Time Ended ____________

Precalibration

Radiometer A

Temperature +25° C

Input Level	Channel 1	Channel 5	Channel 10	Channel 16
-100 dbm	______	______	______	______
- 90 dbm	______	______	______	______
- 80 dbm	______	______	______	______
- 70 dbm	______	______	______	______
- 60 dbm	______	______	______	______
- 50 dbm	______	______	______	______
- 40 dbm	______	______	______	______
- 30 dbm	______	______	______	______
- 20 dbm	______	______	______	______

Test Data Sheet 2.9-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date ____________ Time Started ____________ Time Ended ____________

Precalibration

Radiometer B

Temperature +25° C

Input Level	Channel 1	Channel 5	Channel 10	Channel 16
-100 dbm				
- 90 dbm				
- 80 dbm				
- 70 dbm				
- 60 dbm				
- 50 dbm				
- 40 dbm				
- 30 dbm				
- 20 dbm				

Test Data Sheet 2.9-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ____________ Time Started ____________ Time Ended ____________

Precalibration

Radiometer A

Temperature -10° C

Input Level	Channel 1	Channel 5	Channel 10	Channel 16
-100 dbm				
- 90 dbm				
- 80 dbm				
- 70 dbm				
- 60 dbm				
- 50 dbm				
- 40 dbm				
- 30 dbm				
- 20 dbm				

Test Data Sheet 2.9-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Precalibration

Radiometer B

Temperature -10° C

Input Level	Channel 1	Channel 5	Channel 10	Channel 16
-100 dbm				
- 90 dbm				
- 80 dbm				
- 70 dbm				
- 60 dbm				
- 50 dbm				
- 40 dbm				
- 30 dbm				
- 20 dbm				

Test Data Sheet 2.9-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date __________ Time Started __________ Time Ended __________

Precalibration

Radiometer A

Temperature +40° C

Input Level	Channel 1	Channel 5	Channel 10	Channel 16
-100 dbm				
- 90 dbm				
- 80 dbm				
- 70 dbm				
- 60 dbm				
- 50 dbm				
- 40 dbm				
- 30 dbm				
- 20 dbm				

Test Data Sheet 2.9-1
HELIOS RADIOMETER ______
Radiometer A/B Preamp A/B

Date ________ Time Started ________ Time Ended ________

Precalibration

Radiometer B Temperature +40° C

Input Level	Channel 1	Channel 5	Channel 10	Channel 16
-100 dbm	____	____	____	____
- 90 dbm	____	____	____	____
- 80 dbm	____	____	____	____
- 70 dbm	____	____	____	____
- 60 dbm	____	____	____	____
- 50 dbm	____	____	____	____
- 40 dbm	____	____	____	____
- 30 dbm	____	____	____	____
- 20 dbm	____	____	____	____

2.10 CALIBRATION PROCEDURE FOR EXPERIMENT 5C WITH COMPUTER

2.10.1 Internal Calibration

Radiometer A

Select command 09
Press the "Execute Command" key
Select command 01 (reset)
Press the "Execute Command" key
Select command 20
Press "Execute Command" key

The computer will store the test data on magnetic tape. At the end of the calibration cycle, the computer will stop data storage and print all data which has been stored.

Radiometer B

Select command 10
Press the "Execute Command" key
Select command 01 (reset)
Press the "Execute Command" key
Select command 20
Press "Execute Command" key

The computer will provide data storage during the calibration cycle and a print out after all test data has been accumulated.

2.10.2 Calibration with External Inputs

Radiometer A

Set the bit-rate 1024
Turn on the Experiment 5C
Turn on the DPU
Select command 01 (reset)
Press the "Execute Command" key and wait for 20 seconds
Select command 10 (Radiometer B)
Press the "Execute Command" key and wait for 20 seconds
Select command 09 (Radiometer A)
Press the "Execute Command" key

The computer stores input amplitude versus output amplitude. Each of the 16 channels is monitored 16 times at each input level. The experiment input level is increased 3 db after the 16 frequencies have been monitored. This process continues automatically until the radiometer has been calibrated at 16 frequencies with 129 db to 0 db in 3 db increments. At the end of one complete sequence, the computer will automatically stop data acquisition and will print all data for Radiometer A.

Radiometer B

Select command 10
Press the "Execute Command" key

The computer accumulates and prints the Radiometer B data in the same fashion as it did for Radiometer A.

2.10.3 Environmental Calibration

Install the unit in a temperature chamber and make all necessary electrical connections.
Stabilize chamber at -20° C. Repeat Tests 1 and 2. One must turn the chamber control off while data is accumulated. Noise created by the chamber control circuitry can cause interference which may produce false readings. At the end of each data accumulation period, turn the chamber on and allow at least 15 minutes for restabilization.
Stabilize chamber at 0° C. Repeat Tests 1 and 2.
Stabilize chamber at $+40^\circ$ C. Repeat Tests 1 and 2.
Stabilize chamber at $+60^\circ$ C. Repeat Tests 1 and 2.

3.0 MECHANICAL TESTS

Each unit shall be weighed on a Double Beam Balance. The units shall have covers applied where applicable but shall be less connectors.

Data from this test shall be recorded on Test Data Sheet 3.0-1.

Test Data Sheet 3.0-1
HELIOS RADIOMETER______
Radiometer A/B Preamp A/B

Date__________ Time Started__________ Time Ended__________

Mechanical Tests

Weight (grams)	Unpotted	Potted
Radiometer	______	______
Preamp______	______	______
Preamp______	______	______
Preamp Housing		
before preamp is installed	______	______
Preamp Housing		
after preamp is installed	______	______

COMMAND FUNCTIONS
EXPERIMENT 5C

PART V

Command	Command No.
Reset	01
Frequency Bit - 0	05
Frequency Bit - 1	06
Frequency Bit - 2	07
Frequency Bit - 3	08
MODE Bit - 0	03
MODE Bit - 1	04
MODE Bit - 2	02
RADIOMETER A	09
RADIOMETER B	10
Calibrate	20

DATE		TIME		Test Performed by	
Environmental Conditions				Identity of Test	
Characteristics being Investigated					

Parameter Measurements (or specific test specification paragraph)

Test Equipment Used

Type	Serial #	Calibration Date

Observed Failures

Failure Report #	

Operating Time		

Operational Discrepancies

Repairs and Maintenance

Unusual or Questionable Occurrences

APPENDIX D

CALIBRATION

1.0 CALIBRATION

Calibration of the Radiometers was done differently on each unit.

The flight 1 Prototype was calibrated at GSFC using the Helios Computer. This data is available at GSFC.

The Flight 2 Prototype was hand calibrated at WTA. The data was delivered with the equipment.

The Flight 1 and 2 units were hand calibrated at WTA. The data is on data sheets included in the log books previously delivered.